Pesticide Evaluation Report and Safer Use Action Plan (PERSUAP)

INITIAL ENVIRONMENTAL EXAMINATION AMENDMENT

PROJECT/ACTIVITY DATA

Project/Activity Name:	USAID/Sahel Regional Office: REGIS-ER and USAID|REGIS-AG: Resilience and Economic Growth in the Sahel - Enhanced Resilience (REGIS-ER) & Resilience and Economic Growth in the Sahel - Accelerated Growth USAID (REGIS-AG)
Geographic Location(s) (Country/Region)**:**	Niger and Burkina Faso, Sahel Regional
Amendment (Yes/No),	Yes: PERSUAP
Implementation Start/End Date (FY or M/D/Y)**:**	January 2013
If Amended, specify New End Date:	2013-2018 (REGIS-ER); 2015-2020 (REGIS-AG)
Solicitation/Contract/Award Number:	Cooperative Agreement No. 625-A-14-00001 and Cost Plus Fixed Fee contract AID-625-C-14-00001
Implementing Partner(s):	NCBA CLUSA (lead for REGIS-ER); CNFA (lead for REGIS-AG) ER: Govts of Niger and Burkina Faso; URC, WSA, Sheladia, Dimagi; local NGOs A2N, APOR, ADROC AG: Govts of Niger and Burkina Faso; CRS, VSF, SNV, local NGOs A2N, AGED, AREN, Karkara
AFR Bureau Tracking ID/ECD Link:	Sahel REGIS PERSUAP Niger_Burkina_2018_2020_07.12.2018 https://ecd.usaid.gov/document.php?doc_id=51005
Tracking ID of Related RCE/IEE (if any)**:**	1. #BEO_Sahel JPC REGIS ETD IEE 2012-18 approved 03/31/2015 # https://ecd.usaid.gov/repository/pdf/46156.pdf. 2. DCHA_AFR BEO_REGIS-ER Sahel RISE, approved 01/29/2013 https://ecd.usaid.gov/repository/doc/39036.docx 3. Sahel JPC REGIS-AG & REGIS-ER IEE Amendment-extension January 30, 2018. # BEO_Sahel JPC ETD IEE 2012-2018 https://ecd.usaid.gov/document.php?doc_id=50615
Tracking ID of Other, Related Analyses:	

ORGANIZATIONAL/ADMINISTRATIVE DATA

Implementing Operating Unit(s): (e.g. Mission or Bureau or Office)	AFR, BFS,DCHA
Other Affected Operating Unit(s):	Burkina Faso, Niger
Lead BEO Bureau:	AFR, with stakeholder Bureaux: BFS, DCHA/FFP
Funding Account(s) (if available)**:**	
Original Funding Amount:	
If Amended, specify funding amount:	$70 M +$34.5 M
If Amended, specify new funding total:	$70 M +$34.5M
Prepared by:	Alan Schroeder, PhD, MBA; Dominique Bassole, MSc; and Yaou Salifou, BSc
Date Prepared:	June-Dec. 2017, revised from June 2016 draft. Last revision received from Sahel Reg. Tech. Office on 5/30/2018.

ENVIRONMENTAL COMPLIANCE REVIEW DATA

Analysis Type:	☐ Environmental Examination	☐ Deferral
Environmental Determination(s):	☐ Categorical Exclusion(s) x Negative w/ conditions	☐ Positive ☐ Deferred (per 22CFR216.3(a)(7)(iv)
PERSUAP Expiration Date:	December 31, 2020	
Additional Analyses/Reporting Required:		
Climate Risks Identified (#): N/A	Low ______ Moderate ______	High ______
Climate Risks Addressed (#): N/A	Low ______ Moderate ______	High ______

SUMMARY OF BEO FEEDBACK CONDITIONS, WITH TEAM RESPONSES:

Note from AFR BEO:

This PERSUAP will need to be updated and revised according to the changed operating environment and context of RISE II, to accommodate, among other things, the Fall Armyworm pest management needs and the Feed the Future FAW Management programs.

Condition #1: REGIS should add Fluopyram as a nematicide in the PERSUAP.

Considering that no other nematicides are available for REGIS crops, authors may want to consider authorizing this AI, which would require integrating this AI throughout all necessary components of the PERSUAP. It is recommended that the PERSUAP consider adding Fluopyram as a nematicide. The PERSUAP noted it "is *mistakenly* [sic] registered by INSAH as a nematicide" (p. 24). However, various of the products registered in the US have this AI in their labels as a nematicide (e.g. Luna Privilege, EPA reg. No. 264-1078). Note: Bayer Fluopyram as nematicide:

https://www.cropscience.bayer.us/~/media/Bayer%20CropScience/Country-United-States-Internet/Documents/Products/Insecticides/Velum%20Prime/Velum-Prime-Tech-Bulletin-Citrus.ashx DONE, throughout.

Condition #2: REGIS is required to specify if Fludioxonil, Deltamethrin and Penoxsulam are approved or rejected. BEOs noticed that these three AI's appear to be both in the rejected list and approved lists. As such, it is uncertain as to whether these AI's are approved or rejected. It may be that are different concentrations, formulations, etc or not for same or similar use. However, it lends confusion to the PERSUAP.

Team removed fluioxonil (please note that all pesticide AIs are not capitalized unless they begin a sentence or are used as a pesticide product name, like Malathion) from Annex 4: Analyses of Active Ingredients in Pesticides Registered by INSAH; it was never included in the list of approved pesticides at the front of the document. It is only registered for use on cotton, not a REGIS crop.

Team accepts deltamethrin only for use in contained grain storage bags and warehouses, not field uses, as originally noted in the list of approved pesticides at the front of the document. We add language to the rejected field uses of deltamethrin noting the approved grain storage uses.

Team removed penoxsulam from Annex 4: Analyses of Active Ingredients in Pesticides Registered by INSAH; it was never included in the list of approved pesticides at the front of the document. It is only registered for use on rice, not a REGIS crop.

Condition # 3: REGIS is required to populate the actual SUAP Template with the major actions and provisioning for "who does what by when."—DONE, as much as possible, see pp 53.

Condition # 4: REGIS is invited to refer the IPM content to the content presented in the first round of the REGIS PERSUAP (2016-17)—DONE, see pp 230-242.

Condition # 5: REGIS is required to provide francophone extension materials in the PERSUAP—WILL BE DONE BY REGIS.

Condition #6: REGIS is required to add an additional annex to the final document that includes a short synopsis of affiliations and bios for authors and co-authors—DONE, see pp 260-261.

Note well: Above yellow-highlighted text reflects actions already taken by the Implementing Partners during drafting rounds.

General PERSUAP Conditions

This PERSUAP articulates the mitigating conditions of the REGIS IEE Negative Determination regarding the potential use of pesticides, following 22CFR 216.3 (b) Pesticide Procedures. This PERSUAP will closely inform the technical assistance and capacity building for REGIS supported activities, as well as any partners/sub-grantees, and beneficiaries.

This PERSUAP establishes requirements for safer pesticide use (SPU), particularly the support and use of PPE by all pesticide trainers, promoters, and users. Additionally, the PERSUAP identifies country-level requirements within the framework of a Safer Use Action Plan (SUAP). These and other conditions recommended in the body of this PERSUAP are highlighted and summarized below. They are conditions of the agreement between USAID and REGIS:

A. Only pesticides approved by this PERSUAP (listed above) can be supported by USAID-funded REGIS activities. REGIS will promote only pesticides with pesticides and AIs approved by this PERSUAP.

B. REGIS-funded activities must not support pesticide AIs rejected by this PERSUAP (Annex 9).

C. REGIS should continue to promote Good Agricultural Practices (GAPs) and develop Pest Management Plans (PMPs, see Annexes 2 and 3) adapting/adopting and using recommended detailed preventive IPM tools and tactics provided in Annex 1. REGIS will continue to promote the use of state-of-the-art crop production plans as well as expand and adapt IPM plans included in Annex 1. REGIS should develop more extensive and detailed PMPs that address major pests of program target crops/fruit/livestock and preventive non-chemical IPM tools/tactics recommended to be used before using PERSUAP-approved pesticides. These pesticides should be used only as the last resort after all preventive tools have been exhausted.

D. REGIS should take necessary steps to prevent the development of pest resistance by promoting tools recommended by this PERSUAP (in PER, Section 5, Factor F) such as recommending the rotation among different classes of each type of pesticide and monitoring and record keeping for detecting the possible development of resistance.

Please note: The best strategy is to rotate between pesticides belonging to different mode of action (MoA) groups, rather than to only different chemical classes. Pesticides belonging to different chemical classes may have the same or very similar MoA; e.g., carbamates and organophosphates (belonging to IRAC MoA group 1) are both acetylcholinesterase (AChE) inhibitors, while organochlorine and phenylpyrazoles (belonging to MoA group 2) are both blockers of the GABA-gated chloride channel.

E. Requirement for Safer Pesticide Use Training. REGIS staff and beneficiaries who address pesticides through use of training materials, during training, and on demonstration trials, should promote SPU through explaining pesticide risks, promotion of pesticide best practices, and safety use training. Training should include all topics listed in Annex 6.

F. To the greatest degree practicable, pesticide-related activities that REGIS supports and USAID funds must require use & maintenance of appropriate PPE – as well as use of quality (not fake, adulterate or counterfeit) pesticide purchase, transportation, handling, storage, and disposal practices.

G. Flow down requirements. REGIS must write pesticide compliance requirements as set out above into each grant or sub-contract that may involve support for pesticide use, and sub-contractors or grantees will be responsible for reporting on risk and risk reduction to the Implementing Partner (IP).

In addition, it is ***recommended that REGIS include the following activities in their programs:***

Promoting professional and certified pest control services. REGIS should promote and support the concept and use of a fee-based private-sector pesticide spray services company that have well trained spray personnel protected with appropriate PPE.

Promoting Proper Empty Pesticide Container (EPC) Disposal. REGIS should promote and support the concept and use of EPC best practices, including triple rinsing after last use, puncturing to prevent re-use, burial or municipal disposal. In the future, if a plastics recycling program or company begins operations in the region, EPC recycling could be investigated, including return to collection sites, and recycling into agriculture plastics approved by Governments of Burkina Faso and/or Niger.

USAID CLEARANCE:

CLEARANCE

Mission Director: ____ Date: _______
Lisa Franchett

CONCURRENCE:

Bureau Environment Officer, AFR/SD _________/cleared/_____________ Date: July 11, 2018
Brian Hirsch

[Reviewed through all phases & cleared by Dep. AFR BEO,Walter Knausenberger [2016-2018]

Bureau Environment Officer, DCHA ____//cleared//____________________ Date: Feb 2, 2018

Erika Clesceri

Bureau Environment Officer, BFS ___________/cleared/_________ Date : _June 12, 2018
William Thomas

Filename: __Sahel REGIS PERSUAP Burkina & Niger_2018_2020_07.12.2018______

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Abdourahmane Ndiaye

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Samantha Wapnick

USAID CLEARANCE:

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Filename: Sahel REGIS PERSUAP_Niger-Burkina.71218

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File Name: Sahel REGIS PERSUAP final.71218

Walter Knausenberger <wknausenberger@usaid.gov>

Updated version of REGIS's PERSUAP

William Thomas <withomas@usaid.gov> Tue, Jun 12, 2018 at 3:42 PM
To: Abdourahmane Ndiaye <abndiaye@usaid.gov>
Cc: Walter Knausenberger <wknausenberger@usaid.gov>, Brian Hirsch <bhirsch@usaid.gov>, Erika Clesceri <eclesceri@usaid.gov>, Samantha Wapnick <swapnick@usaid.gov>, AFRBEO-Support <AFRBEO-support@cadmusgroup.com>, "GEMS Env Support (USAID)" <gemsenvsupport@usaid.gov>, DCHA GEMS Support <DCHAGemsSupport@smtn.org>, Patrick Smith <pasmith@usaid.gov>, Doudou Ndiaye <dndiaye@usaid.gov>

All -
Overall the content of this PERSUAP is good.
However, a few very simple edits can make it more user friendly and field usable. Specifically:

- Annex 1: IPM Matrix for REGIS Crops, Livestock, Primary Pests, Diseases, and Weeds, pages 56-203
  - All tables need to have the header (column information / table context) appear on each page. This can be accomplished by selecting the header row and checking the '*Repeat as header row at the top of each page*' in Table Properties under the Row tab.
- Annex 4: Analyses of Active Ingredients in Pesticides Registered by INSAH, pages 211-215
  - All tables need rows and columns with visually clear borders.
- Annex 9: Summary of Pesticide AIs Registered by INSAH and Rejected by this PERSUAP Analysis, pages 245-256
  - All tables in this section need to have the header appear on each page. In addition, clearly state on each and every page that US funds cannot be utilized to purchase or otherwise support the pesticides listed.

With these changes I will clear.
-- Bill

Bill Thomas, *Bureau Environmental Officer,* **Bureau for Food Security**
United States Agency for International Development
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On Wed, May 30, 2018 at 4:25 AM, Abdourahmane Ndiaye <abndiaye@usaid.gov> wrote:
[Quoted text hidden]

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ACRONYMS

A/COR	Agreement/Contracting Officer's Representative (USAID)
AI	Active Ingredient (reference to chemical/s in pesticides)
BEO	Bureau Environmental Officer (USAID)
BT	Bacillus thuringiensis (a bacterium that produces a toxin that is used as a pesticide)
CBMV	Cucumber Mosaic Virus
CBSP	Community Based Solution Provider
CCFC	Commonly Consumed Food Commodities
CFR	Code of Federal Regulations (USA)
CILSS	Comité permanent inter-État de lutte contre la sécheresse au Sahel
CLI	Crop Life International (private sector pesticide trade association)
CMV	Cassava Mosaic Virus
CPMV	Cowpea Mosaic Virus
CTV	Citrus Tristeza Virus
DCHA	Bureau for Democracy, Conflict and Humanitarian Assistance (USAID)
EA	Environmental Assessment (USAID)
EC	Emulsifiable Concentrate (pesticide formulation)
ECPA	European Crop Protection Association
EMMP	Environmental Mitigation and Monitoring Plan (USAID)
EPA	Environmental Protection Agency (USA, also known as USEPA)
EPC	Empty Pesticide Container
EU	European Union
FAO	Food and Agriculture Organization (United Nations)
FFP	Food for Peace
FIFRA	Federal Insecticide, Fungicide and Rodenticide Act (USA)
FRAC	Fungicide Resistance Action Committee
G	Granular (a pesticide formulation)
GAP	Good Agriculture Practice
GlobalGAP	Global Good Agriculture Practices, a quality certification system
GUP	General Use Pesticide
HLB	Huang Long Bing (citrus disease)
HRAC	Herbicide Resistance Action Committee
HT	Highly Toxic
IEE	Initial Environmental Examination (USAID)
IITA	International Institute for Tropical Agriculture

INSAH	Institut du Sahel
IP	Implementing Partner
IPM	integrated pest management
IRAC	Insecticide Resistance Action Committee
ISO	International Standards Organization
IVM	Integrated Vector Management
IVM	Integrated Vector Management
IWM	Integrated Weed Management
LCV	leaf curl virus (sesame)
LOE	level of effort
M&E	Monitoring and Evaluation
MASL	meters above sea level
MEO	Mission Environmental Officer (USAID)
MOA	Ministry of Agriculture
MRL	Maximum/Minimum Residue Level/Limit
MRP	Minimum Risk Pesticides
MRP	Minimum Risk Pesticides (MRP
MSDS	Material Safety Data Sheet
MSV	Maize Streak Virus
MT	Moderately Toxic
NAT	Not Acutely Toxic
NCBA-CLUSA	National Cooperative Business Association, Cooperative League of the USA
NGO	Non-Governmental Organization
OD	Oil Dispersion (a pesticide formulation)
OkLCV	Okra leaf curl virus
OkMV	Okra mosaic virus
OkYVMV	Okra yellow vein mosaic virus
PAN	Pesticide Action Network (pesticide NGO)
PCV	Peanut Clump Virus
PER	Pesticide Evaluation Report
PERSUAP	Pesticide Evaluation Report and Safer Use Action Plan
PGR	Plant Growth Regulator (type of herbicide)
pH	log of hydrogen concentration, measure of acidity
PHI	Pre-Harvest Interval
PIC	Prior Informed Consent (a treaty, relates to toxic pesticides)

PLRV	Potato Leaf Roll Virus
PMP	Pest Management Plan
POP	Persistent Organic Pollutants (a treaty, relates to toxic persistent pesticides)
PPE	Personal Protection Equipment
PRSV	Papaya ring spot virus
PVMV	Pepper Veinal Mottle Virus
PVY	Potato Virus Y
PXV	Potato X Virus
RD	Reproductive and Developmental (type of chronic human toxin)
Reg 216	Regulation 216 (USAID Environmental Procedures under 22 CFR 216.3 (b))
REGIS-AG	Resilience and Economic Growth in the Sahel - Accelerated Growth
REGIS-ER	Resilience and Economic Growth in the Sahel - Economic Resilience
REI	Re-Entry Interval (safety period after pesticide spraying)
RISE	Resilience in the Sahel Enhanced (another USAID initiative)
RUP	Restricted Use Pesticide
RV	Rosette Virus (groundnut)
S&C	Standards and Certification
SAPHYTO	African Society of Phytosanitary Products and Insecticides
SC	Suspension Concentrate (a pesticide formulation)
SL	Soluble Liquid (a pesticide formulation)
SPCSV	Sweet Potato Chlorotic Stunt Crinivirus
SPFMV	Sweet Potato Feathery Mottle Potyvirus
SPU	Safe Pesticide Use
SS/EA	Scoping Statement and Environmental Assessment
ST	Slightly Toxic
SUAP	Safe Use Action Plan
TMV	Tobacco/Tomato Mosaic Virus
TYLCV	Tomato leaf yellow curl virus
UN	United Nations
UNEP	UN Environment Program
UNFAO	UN Food and Agriculture Organization (also known as FAO)
US	United States
USAID	US Agency for International Development
USDA	US Department of Agriculture
USEPA	US Environmental Protection Agency (also known as EPA)

VC	value chains
WG	Water Dispersible Granule (a pesticide formulation, prior name WDG)
WHO	World Health Organization (United Nations)
WMV	Watermelon mosaic virus
WP	Wettable Powder (a pesticide formulation, usually for fungicides)
ZYMV	Zucchini yellow mosaic virus

SECTION 1: INTRODUCTION AND EXECUTIVE SUMMARY

The purpose of this document is to conduct a re-write of a Pesticide Evaluation Report (PER) and Safe Use Action Plan (SUAP) to bring USAID/Senegal/Sahel Regional Office -funded projects in Niger and Burkina Faso into compliance with USAID's 1975 environmental regulations (Title 22 of the Code of Federal Regulations (CFR), part 216, or Regulation 216.3) on pesticide use, modeled after regulations of the US EPA (Environmental Protection Agency). Beyond compliance, this document offers a selection of best practices and pest prevention tools to help ensure that projects can use as a base for adapting and adoption, with their own local best practices and pest monitoring levels. Since 1990, USAID has promoted, as policy, integrated pest management (IPM), and desires a thorough examination of preventive non-pesticide tools and tactics, as well as the prudent selection of effective pesticides one could use while following certain precautions and protections.

If a USAID-funded project desires to promote or use a pesticide rejected by this PERSUAP analysis, it will be required to perform a Scoping Statement and Environmental Assessment (SS/EA) to evaluate, in detail, the potential environmental and human health impacts of the use of those chemicals, as well as ways to reduce those risks.

The Resilience and Economic Growth in the Sahel (REGIS) program is a USAID-funded contract with offices and field stations in Niger and Burkina Faso. REGIS-AG (Accelerated Growth) and REGIS-ER (Enhance Resilience) have offices in the city of Niamey and operate in Zinder, Maradi and Tillaberi, with another office in Ouagadougou, Burkina Faso with field operations in Dori and Kaya. Through REGIS-AG, CNFA offers a robust strategy for strengthening cowpea, small ruminant and poultry value chains (VCs) in agro-pastoralist and marginal agricultural zones of Niger and Burkina Faso. By transforming value chain relationships and dynamics to increase their inclusiveness as well as their competitiveness, REGIS-AG will increase the incomes of vulnerable households and build the resilience of families and communities to shocks such as drought, conflict and economic crises.

The sister REGIS-ER (Enhance Resilience) project focuses on the root causes of chronic vulnerability by increasing the capacity of households, villages and systems to adapt to and recover from shocks and stresses. REGIS- ER integrates sustainable livelihoods, natural resource management, governance, health and nutrition activities in collaboration with local communities. One of REGIS-ER's objectives is on diversified economic opportunities, intensified climate-smart agricultural and animal production and marketing, and increased access to financial services. It focuses on smallholder subsistence nutritional garden crops and livestock, listed below.

As part of the REGIS-AG contract, CNFA is responsible for completing a PERSUAP and USAID has directed the organization to create a combined PERSUAP between REGIS-AG and REGIS-ER. Therefore, this activity will capture information for both USAID-funded projects implemented in Burkina Faso and Niger. In May 2016, a forester with the National Cooperative Business Association, Cooperative League of the USA (NCBA-CLUSA), the lead implementer for REGIS-ER, used a flawed 2014/2015 DFAP PERSUAP as a model and drafted a joint PERSUAP for the two projects, but USAID did not accept that version. USAID/DCHA and AF/Bureau requested that the projects recomplete the activity. This PERSUAP is a result of that request.

Risks: Risks are inevitably present with the use of pesticides for agricultural crop, livestock and poultry production. In addition to required compliance, this PERSUAP provides project implementers with the most common risks discovered and likely to be encountered. Projects can use these risks to inform and guide their own development of an environmental risk monitoring, mitigation and reporting plan (EMMP), as USAID requires.

As part of risk-reduction, the REGIS projects have been eager to provide general best practices training on preventive non-chemical integrated pest management (IPM) tools and tactics, the use of natural artisanal plant and spice extracts to repel pests from crops, and general safe pesticide use (SPU) practices.

Target Crops/Livestock: The two REGIS projects provide access to improved planting material, best practices advice, and assistance on improving production of the following crops, livestock and poultry, compiled by type:

- Food Security Crops: cassava, cowpea, groundnuts, maize, millet, sorghum, and soybean for chicken food
- Garden and Cash Crops: Amaranthus leaves, cabbage, carrots, Corchorus leaves, Cucurbits: cucumber, pumpkin, squash, watermelon, cantaloupe; Solanaceous Crops (garden and cash crops): Irish potato; tomato; peppers (hot/sweet); eggplant; Allium Crops: onion, garlic; Hibiscus flowers, lettuce, Moringa tree leaves, okra, Senna obtusifolia leaves, sesame, sweet potato
- Livestock/Fowl: goats, sheep, poultry
- Fruits: citrus, mango, papaya, Sahel apple
- Fodder: dolique bean

Crop/Livestock Production Constraints and IPM: Key production constraints consisting of pests, diseases and weeds of each crop are compiled by project technical experts, by species if known, in Annex 1, an IPM matrix. This IPM matrix contains descriptions of each pest or disease as well as damages they cause. Further, it includes preventive non-chemical IPM tools and tactics proposed and used in other countries and regions, as well as PERSUAP-approved pesticide active ingredients (AIs) and product Trade Names registered by INSAH (Institut du Sahel) for member (French-speaking) countries, including Niger and Burkina Faso.

Approved Pesticides for Use Against Key Crop Production Constraints: Upon approval of this PERSUAP, the below-listed AIs and pesticides are permitted for support, promotion and use with USAID funds on REGIS AG and ER activities. This approval is subject to compliance with general conditions that none of the following be used: no USEPA Acute Toxicity Category I or World Health Organization (WHO) Acute Toxicity Class Ia or Ib products, no Restricted Use Products (RUP), no known carcinogens, and no known water pollutants. REGIS projects will also train farmers on following the pesticide container label and Material Safety Data Sheet (MSDS) precautions, using appropriate Personal Protection Equipment (PPE), and any additional conditions listed for each pesticide/AI in the table below. The list is organized by type of pesticide (fungicides; herbicides; insecticides/miticides and rodenticide), and by INSAH's approval number for alphabetized pesticide AIs, mixtures of AIs and products.

Table 1. PERSUAP-Approved Pesticide Active Ingredients (with French spellings, as used locally) and INSAH-Registered Products (with specific conditions and recommendations)

Fungicide AIs in products registered by INSAH (with specific conditions or restrictions for use, and condition that label instructions be followed)

INSAH No	Active Ingredient (I = insecticide)	Product Names with Formulation, if known	Concentration	WHO acute toxicity as listed by INSAH	Summary of Special Restrictions
12 13	*Aspergillus flavus* strains: MO11-8; GO18-2; M109-2; M110-7 *Aspergillus flavus* strains: SS19-14; MS 14-19; M2-7; M21-11	Aflasafe BF 01 Aflasafe SN 01	10ml/kg 10ml/kg	- -	
36 289 290	azoxystrobin " azoxystrobin + difenoconazole	Azox Ortiva 250 SC Ortiva Top	250g/l 250g/l 200g/l + 125g/l	III III III	
220	chlorothalonil	Jumper 75 WG	75g/kg	U	

Table 1. PERSUAP-Approved Pesticide Active Ingredients (with French spellings, as used locally) and INSAH-Registered Products (with specific conditions and recommendations)

Fungicide AIs in products registered by INSAH (with specific conditions or restrictions for use, and condition that label instructions be followed)

28	difenoconazole + méfenoxam + thiamethoxam (I)	Apron Star 42 WS	20g/kg 200g/kg 200g/kg	III	for seed treatment only
124 263 77 77 219	mancozeb “ “ “ “	Dithane M45 Manco 80 WP Coga 80 WP Manga Plus Ivory 80 WP	800g/kg 800g/kg 800g/kg 800g/kg 800g/kg	III U III III III	
69/70	métalaxyl + imidaclopride (I) + thirame	Calthio mix 485 WS--seed treatment only by professionals	35g/kg + 350 g/kg + 100 g/kg	II	thirame in powder form is too toxic for smallholder farmers to use--only for use by seed treatment professionals
274	tébuconazole + trifloxystrobin	Nativo 300 SC	200g/kg + 100g/kg	II	
57	thirame + perméthrine (I)	Caiman Rouge P	250g/kg + 25g/kg	II	thirame in powder form is too toxic for smallholder

Table 1. PERSUAP-Approved Pesticide Active Ingredients (with French spellings, as used locally) and INSAH-Registered Products (with specific conditions and recommendations)					
Fungicide AIs in products registered by INSAH (with specific conditions or restrictions for use, and condition that label instructions be followed)					
70 216 269	thirame + imidaclopride (I) + métalaxyl thirame + imidaclopride (I) thirame + imidaclopride (I)	Calthio Mix 485 WS Insector T Momtaz 45 WS	100g/kg + 350g/kg + 35g/kg 100g/kg + 350g/kg 200g/kg +	II III III	farmers to use--only for use by seed treatment professionals
Herbicide AIs in products registered by INSAH (with specific conditions or restrictions for use, and condition that label instructions be followed)					
INSAH No	**Active Ingredient**	**Product Names with Formulation, if known**	**Concentration**	**WHO acute toxicity**	**Summary of Special Restrictions**
46 199 366 408	2,4-D “ “ “	Binbefla Plus 720 Herbexbar 720 SL Soundiata 720 SL Topextra 720 SL	720g/l 720g/l 720g/l 720g/l	III III II II	In the US, all product with >20-30% AI are EPA class I
63/64 108	2,4-D diméthylamine “	Calliherbe 720 SL	720g/l 720g/l	II III	

Table 1. PERSUAP-Approved Pesticide Active Ingredients (with French spellings, as used locally) and INSAH-Registered Products (with specific conditions and recommendations)

Fungicide AIs in products registered by INSAH (with specific conditions or restrictions for use, and condition that label instructions be followed)

377		Dekade Sun-2,4D Amine	720g/l	II	
358-361	cléthodim (also PGR)	Select 120 SC	120g/l	III	
128	glyphosate	Douma Woro 480	480g/l	II	Avoid widespread use of glyphosate due to concerns about persistence and water contamination.
157	“	Finish 68 SG	680g/kg	III	
161	“	Fouralan 480 SL	480g/l	III	
172	“	Glycel 410 SL	410g/l	II	
176	“	Glyphader 75 SG	750g/kg	III	
177	“	Glyphalm 360 SL	360g/l	III	
181	“	Glyphogan 480 SL	480g/l	III	
183	“		360g/l	III	
184	“	Glyphonet 360 SL	480g/l	III	
198	“	Glyphotrop 480 SL	360g/l	III	
224	“		360g/l	III	
228	“	Herbasate	480g/l	U	
230	“	Kalach/Heros 360	360g/l	U	
237	“	Killer 480 SL	360g/l	III	
238	“	Koglypho 360 SL	757g/kg	III	
262	“		360g/l	III	

Table 1. PERSUAP-Approved Pesticide Active Ingredients (with French spellings, as used locally) and INSAH-Registered Products (with specific conditions and recommendations)					
Fungicide AIs in products registered by INSAH (with specific conditions or restrictions for use, and condition that label instructions be followed)					
344	“	Lamachette 360 SL	360g/l	III	
346	“	Lamachette 757 SL	680g/kg	III	
347	“		540g/l	III	
411	“	Mamba 360 SL	500g/l	III	
		Rival 360 SL			
		Roundup 680 Biose			
		Roundup Powerma			
		Touchdown Forte 500 SL			
17	nicosulfuron	Akizon 40 SC	40g/l	III	
18	“	Akoumais 40 SC	40g/l	III	
221	“	Kababin 40 SC	40g/l	III	
258	“	Maia 75 WG	750g/kg	III	
259	“	Maia Super	60g/l	III	
275	“	Nico Top 40 AD	40g/l	U	
276	“	Nicodaf 40 SC	40g/l	III	
277	“	Nicokaba 40 SC	40g/l	III	
278	“	Nicomais 40 SC	40g/l	III	
279	“	Niconet 40 SC	40g/l	U	

Table 1. PERSUAP-Approved Pesticide Active Ingredients (with French spellings, as used locally) and INSAH-Registered Products (with specific conditions and recommendations)

Fungicide AIs in products registered by INSAH (with specific conditions or restrictions for use, and condition that label instructions be followed)

280 357 363	“ “ “	Nicosuper 40 SC Segaibaana 40 SC Sofa 40 SC	40g/l 40g/l 40g/l	U U U	
292	oxadiazon	Oxo 250 EC	250g/l	III	
188	oxyfluorfene	Goal 2E	240g/l	III	
21/22 296-8 299 300 301/2 304 368-70	pendiméthaline “ “ “ “ “ “ pendiméthaline + clomazone	Alligator Pencal/Paragon 500 EC Pendaf 500 EC Pendinet 500 EC Pendistar Penditrop 500 EC Stomp CS/ Alligator Unik	400g/l 500g/l 500g/l 500g/l 400g/l 500g/l 455g/l	III II III III III III II	
341 352	rimsulfuron “	Ricomais 25 WG Saphir	250g/l 30g/l	U III	

Table 1. PERSUAP-Approved Pesticide Active Ingredients (with French spellings, as used locally) and INSAH-Registered Products (with specific conditions and recommendations)					
Fungicide AIs in products registered by INSAH (with specific conditions or restrictions for use, and condition that label instructions be followed)					
Insecticide and miticide (where listed) AIs in products registered by INSAH (with specific conditions or restrictions for use, and condition that label instructions be followed)					
INSAH No	**Active Ingredient** **(F = fungicide)**	**Product Names with Formulation, if known**	**Concentration**	**WHO acute toxicity**	**Summary of Special Restrictions**
2 3 53 416	abamectine (miticide/insecticide) “ “	Abalone 18 EC Acarius 18 EC Bomec 18 EC Vertimec 18 EC	18g/l 18g/l 18g/l 18g/l	II II II II	
404	acétamipride	Titan 25 EC	25g/l	II	For use only during crop vegetative stages; not for use during flowering
40 51	BT/ *Bacillus thuringiensis* var. Kurstaki	Batik WG Bio K 16	32,000IU/mg 16,000IU/mg	III U	
340	chlorpyrifos-méthyl	Reldan 40 EC	400g/l	III	Not for use on field agriculture or horticulture Class I--only for

Table 1. PERSUAP-Approved Pesticide Active Ingredients (with French spellings, as used locally) and INSAH-Registered Products (with specific conditions and recommendations)					
Fungicide AIs in products registered by INSAH (with specific conditions or restrictions for use, and condition that label instructions be followed)					
					use by professionals in grain storage warehouses
318 425	deltaméthrine + pirimiphos-méthyl deltaméthrine	Protect DP Zerofly Storage Bag	1g/kg + 15g/kg 3g/l	III III	Not for use on field agriculture or horticulture--only for use by professionals in grain storage sacks and warehouses
267	diméthoate	Methoate 40 EC	400g/l	II	
69/70 216 269	imidaclopride + thirame (F) + métalaxyl (F) imidaclopride + thirame (F) imidaclopride + thirame (F)	Calthio Mix 485 WS Insector T Momtaz 45 WS	350g/kg + 100g/kg + 35g/kg 350g/kg + 100g/kg 250g/kg + 200g/kg	II III III	thirame in powder form is too toxic for smallholder farmers to use--only for use by seed treatment professionals

Table 1. PERSUAP-Approved Pesticide Active Ingredients (with French spellings, as used locally) and INSAH-Registered Products (with specific conditions and recommendations)					
Fungicide AIs in products registered by INSAH (with specific conditions or restrictions for use, and condition that label instructions be followed)					
382	kaolin clay/aluminum silicate	Surround WP Crop Protectant	95%	II	
165 218	malathion “	Fyfanon 880 EC Invader-B-Lock	880g/l 4.5g/bloc	III U	
8 25	perméthrine + pirimiphos-méthyl perméthrine + pirimiphos-méthyl	Actellic Super Dust Antouka 19 DP	3g/kg + 16g/kg 3g/kg + 16g/kg	III III	only for use on stored grain by professionals -- Not for use in the field on crops
57	perméthrine + thirame (F)	Caiman Rouge P	25g/kg + 250g/kg	II	thirame in powder form is too toxic for smallholder farmers to use-- only for use by seed treatment professionals
7	pyrimiphos-méthyl + thiamethoxam	Actellic Gold Dust	16g/kg + 3.6g/kg	U	only for use on stored grain by professionals --

Table 1. PERSUAP-Approved Pesticide Active Ingredients (with French spellings, as used locally) and INSAH-Registered Products (with specific conditions and recommendations)					
Fungicide AIs in products registered by INSAH (with specific conditions or restrictions for use, and condition that label instructions be followed)					
					Not for use in the field on crops
247-8 367 371	spinosad “ “	Laser 480 EC Spintor Poudre Success Appat 0.24 CB	480g/l 1.25g/kg 0.24g/l	III U III	Spintor Poudre only for use on stored grain-- Not for use in the field on crops, Laser 480 EC Success Appat 0.24 CB approved for field use
264	*Tagetes African Marigold* oil + thyme oil (also miticide)	Marigold	5.52g/l + 5.52g/l	U	
28	thiamethoxam + mefenoxam (F)+ difenoconazole (F)	Apron Star 42 WS	200g/kg + 200g/kg + 20g/kg	III	for seed treatment only
Nematicide AI in one product registered by INSAH (with specific conditions or restrictions for use, and condition that label instructions be followed)					

Table 1. PERSUAP-Approved Pesticide Active Ingredients (with French spellings, as used locally) and INSAH-Registered Products (with specific conditions and recommendations)					
Fungicide AIs in products registered by INSAH (with specific conditions or restrictions for use, and condition that label instructions be followed)					
INSAH No	**Active Ingredient**	**Product Names with Formulation, if known**	**Concentration**	**WHO acute toxicity**	**Summary of Special Restrictions**
415	fluopyram	Velum Prime 400 SC	41.5%	III	
Rodenticide AI in one product registered by INSAH (with specific conditions or restrictions for use, and condition that label instructions be followed)					
INSAH No	**Active Ingredient**	**Product Names with Formulation, if known**	**Concentration**	**WHO acute toxicity**	**Summary of Special Restrictions**
417	brodifacoum	Vertox Pellets	0.005%	III	for use only in plastic bait boxes away from children and domestic animals

Rejected pesticides: Pesticides AIs and Trade Names of pesticides rejected by this PERSUAP are listed in Annex 9 at the end of this document, with reasons for each rejection. Many AIs are rejected outright if they are: not in products registered by EPA; in EPA-designated RUPs; EPA Class I or WHO Classes Ia or Ib acute toxicity; known carcinogens; or known water pollutants. Other pesticide AIs and Products are rejected because they are registered for malarial vector control or domestic use sectors, or because they are registered for use against locust plagues or registered for use on high-value cash crops such as cotton, sugar cane and rice, none of which USAID or REGIS supports.

What report findings do and do not mean: USAID projects can promote, purchase or donate pesticides, training, advice and application equipment if the risks associated with them have been evaluated in a PERSUAP. Note that farmers can—with their own funding—buy and use the pesticides they want, if they or their farm are not part of (not funded by) a USAID project (not used as a demonstration farm), not used in USAID-procured application equipment, and the treated produce does not enter a USAID-funded export, marketing or sales program.

Low-risk Pesticide AIs not requiring approval under this PERSUAP: Note that some particularly low-risk AIs (primarily extracts from plants, often artisanal or homemade by smallholder farmers) are exempt from regulation under the US Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) and therefore may be made and used by beneficiary farmers without approval via this PERSUAP.

Some of these products are labeled as Minimum Risk Pesticides (MRP) and are listed at:

http://www.epa.gov/sites/production/files/2015-12/documents/minrisk-active-ingredients-tolerances-2015-12-15.pdf. A list of pesticide Inert Ingredients that are exempt from FIFRA is:

http://www.epa.gov/sites/production/files/2015-01/documents/section25b_inerts.pdf. And, so-called Commonly Consumed Food Commodities (CCFC), which include spices, herbs and oils that may be used by smallholder farmers as homemade pesticides are found at: https://www.epa.gov/minimum-risk-pesticides/commonly-consumed-food-commodities.

Insect Pheromones: Pheromones, even though listed/categorized as biochemical pesticides (biopesticides) by EPA, are covered under EPA's new "Pheromone Regulatory Relief" as lower risk, and therefore, are not subject to regulation under FIFRA, and as such, are exempt from EPA registration, and PERSUAP analysis.

See https://www.epa.gov/sites/production/files/2015-08/documents/biopesticide-oversight-chapter_0.pdf, and https://www.epa.gov/pesticide-registration/pesticide-registration-manual-chapter-3-additional-considerations.

Currently, pheromone technology is used on a small scale in Niger and Burkina Faso, and could become a focus of use on USAID projects, where it makes sense. Parts of Annex 1 recommend the use of some pheromone pest traps. Pheromones could become particularly useful in the fight against the moths of many Lepidopterous pests and caterpillars, like the *Tuta absoluta* tomato leaf miner.

Pesticide Acute Toxicity: Toxicity of a substance is generally determined by the concentration of that substance. Note that EPA's classification system for determining pesticide acute toxicity (used only in the USA) varies from World Health Organization (WHO) system (used by most other countries of the world). Ideally, USAID projects would reject use of EPA Class I and WHO

Classes Ia and Ib products, because they are too toxic for smallholder farmers to use and too risky for USAID projects to support. Class I chemicals should only be used by properly trained and protected professional application services.

Unregistered and Counterfeit Pesticides: Pesticides not registered by INSAH are found in non-INSAH countries Nigeria and Ghana, which share a border with Niger and Burkina Faso, respectively. Some of these pesticides are counterfeit, often made in China, and are imported illegally into Niger and Burkina Faso. Advice is provided later in this report, so that USAID-funded projects can recognize and discourage the use of such products.

Village Brigades: To enhance village crop protection abilities, country Ministries of Agriculture (MOAs) in West Africa, including those in Burkina Faso and Niger, have organized groups of individuals, by village, with pesticide sprayers, PPE and training on SPU primarily for outbreaks of pests like locusts and grasshoppers that attack crops on a large scale across a village or region. These are not the same as private spray service applicators, who have even more training, information, skills and personal protection.

GENERAL PERSUAP CONDITIONS

This PERSUAP articulates the mitigating conditions of the REGIS IEE Negative Determination regarding the potential use of pesticides, following 22CFR 216.3 (b) Pesticide Procedures. This PERSUAP will closely inform the technical assistance and capacity building for REGIS supported activities, as well as any partners/sub-grantees, and beneficiaries.

This PERSUAP establishes requirements for safer pesticide use (SPU), particularly the support and use of PPE by all pesticide trainers, promoters, and users. Additionally, the PERSUAP identifies country-level requirements within the framework of a Safer Use Action Plan (SUAP). These and other conditions recommended in the body of this PERSUAP are highlighted and summarized below. They are conditions of the agreement between USAID and REGIS:

1. Only pesticides approved by this PERSUAP (listed above) can be supported by USAID-funded REGIS activities. REGIS will promote only pesticides with pesticides and AIs approved by this PERSUAP.

2. REGIS-funded activities must not support pesticide AIs rejected by this PERSUAP (Annex 9).

3. REGIS should continue to promote Good Agricultural Practices (GAPs) and develop Pest Management Plans (PMPs, see Annexes 2 and 3) adapting/adopting and using recommended detailed preventive IPM tools and tactics provided in Annex 1. REGIS will continue to promote the use of state-of-the-art crop production plans as well as expand and adapt IPM plans included in Annex 1. REGIS should develop more extensive and detailed PMPs that address major pests of program target crops/fruit/livestock and preventive non-chemical IPM tools/tactics recommended to be used before using PERSUAP-approved pesticides. These pesticides should be used only as the last resort after all preventive tools have been exhausted.

4. REGIS should take necessary steps to prevent the development of pest resistance by promoting tools recommended by this PERSUAP (in PER, Section 5, Factor F) such as recommending the rotation among different classes of each type of pesticide and monitoring and record keeping for detecting the possible development of resistance.

Please note: The best strategy is to rotate between pesticides belonging to different mode of action (MoA) groups, rather than to only different chemical classes. Pesticides belonging to different chemical classes may have the same or very similar MoA; e.g., carbamates and organophosphates (belonging to IRAC MoA group 1) are both acetylcholinesterase (AChE) inhibitors, while organochlorine and phenylpyrazoles (belonging to MoA group 2) are both blockers of the GABA-gated chloride channel.

5. Requirement for Safer Pesticide Use Training. REGIS staff and beneficiaries who address pesticides through use of training materials, during training, and on demonstration trials, should promote SPU through explaining pesticide risks, promotion of pesticide best practices, and safety use training. Training should include all topics listed in Annex 6.

6. To the greatest degree practicable, pesticide-related activities that REGIS supports and USAID funds must require use & maintenance of appropriate PPE – as well as use of quality (not fake, adultered or counterfeit) pesticide purchase, transportation, handling, storage, and disposal practices.

7. Flow down requirements. REGIS must write pesticide compliance requirements as set out above into each grant or sub-contract that may involve support for pesticide use, and sub-contractors or grantees will be responsible for reporting on risk and risk reduction to the Implementing Partner (IP).

In addition, it is recommended that REGIS include the following activities in their programs:

Promoting professional and certified pest control services. REGIS should promote and support the concept and use of a fee-based private-sector pesticide spray services company that have well trained spray personnel protected with appropriate PPE.

Promoting Proper Empty Pesticide Container (EPC) Disposal. REGIS should promote and support the concept and use of EPC best practices, including triple rinsing after last use, puncturing to prevent re-use, burial or municipal disposal. In the future, if a plastics recycling program or company begins operations in the region, EPC recycling could be investigated, including return to collection sites, and recycling into agriculture plastics approved by Governments of Burkina Faso and/or Niger.

SECTION 2: BACKGROUND

Burkina Faso

Burkina Faso is a landlocked West African country, bordered by Mali in the north and west, Niger in the East, and Benin, Togo, Ghana, and Côte d'Ivoire in the south. Burkina Faso covers a land area of 274,200 km^2.

Much of Burkina Faso lies on a savanna plateau, 200-300 meters above sea level (MASL), and is generally characterized by a tropical climate of the Sudanese and Sahelian categories, with a long dry season from October to April, and a short rainy season from May to September. The arid Sahelian zone covers the northern part of the country, and has an annual rainfall that does not exceed 350-500 mm in most areas. The Sudanese zone is less arid and covers the southern part of the country, receiving annual rainfall that varies from 700 mm to 1200 mm.

Most Burkina Faso's streams are seasonal, with only the Mouhoun, the Comoé, and the Pendjari having perennial flows. Major seasonal streams include the Nazinon, the Nakambé, and the Sirba. Other perennial bodies of water include Bam and Dem lakes, Mare aux Hippopotames, the Oursi Pond, and the artificial lakes of Kompienga, Bagré, and Ziga. Since 2006, the latter has served as a major supplementary source of drinking water for Ouagadougou and its surrounding localities.

Burkina Faso's economy is dominated by subsistence agriculture in which 90 % of the population engages (accounting for 37% of GDP). Principle crops include sorghum, millet, maize, rice, cowpea, groundnuts, sesame, cassava, Irish potatoes and sweet potatoes. Cash crops include cotton, tobacco and sugarcane.

Niger

Niger is a land-locked country with a land area of 1,267,000 km^2. Seven other countries surround it, with Nigeria to the south, Chad to the east, Algeria to the north-northwest, and Mali to the west. Niger also has short borders in its far southwest frontier with Burkina Faso and Benin, and to the north-northeast Libya.

Niger's climate is largely hot and dry, with primarily desert in the north. Niger receives most of its rain between June and September, and rainfall totals of more than 500 mm during this season typically provide enough water for crops and livestock. Only 15% of Niger's land is arable, and that is mostly located along the southern border with Nigeria. In this extreme south, there is a sub-tropical climate along the edges of the Niger River Basin. The terrain further north is predominantly desert plains and sand dunes, with flat to rolling plains to the south and hills in the north.

Agricultural lands in Niger are used as arable, especially near water sources, and as pasture. There are some forests and woodland in the south and around desert wadis (oases). Recurring droughts are a challenge in Niger. The 2012 Sahel drought, which led to failed crops, increased insect plagues, high food prices and conflicts continue to affect Niger, and often leads to acute food shortages.

Agriculture in Niger accounts for 40% of GDP and employs over 90% of the workforce. Primary crops and livestock include cowpeas, cotton, peanuts, millet, sorghum, cassava, rice; cattle, sheep, goats, camels, donkeys, horses, poultry.

REGIS-AG Background

Because of long-term and large-scale humanitarian emergencies in the Sahel, USAID recognized that continuing to treat these recurrent crises as acute emergencies is extremely costly and does not effectively address the underlying causes. Thus, USAID's Resilience in the Sahel Enhanced (RISE) initiative has realigned existing and new humanitarian and development assistance efforts to strengthen resilience in agro-pastoral and marginal agriculture livelihood zones of the Sahel. USAID is reducing chronic vulnerability by increasing economic well-being, strengthening institutions and governance, and improving health and nutrition status. REGIS-AG is one of the RISE initiative's three key projects that work to end the vicious cycle of crisis and help the Sahel's most vulnerable population stay firmly on the path to development.

REGIS-AG is working to translate improved value chain performance for cowpea, small ruminants and poultry into incomes for vulnerable populations by:

- Identifying opportunities to improve targeted market systems and ensuring the poor's ability to access and compete in markets
- Improving post-production market systems including storage, aggregation, processing, transport, marketing and related services that are poorly developed in many agricultural and livestock value chains and are an important potential source of employment and income
- Increasing access to inputs and support services that will enable men and women in vulnerable households to make the investments needed to participate successfully in promising value chains
- Increasing access to finance, innovation, and private sector investment which will broaden and deepen markets without causing disruptions
- Improving the enabling environment to provide incentives and reduce risks for households to invest in new technologies and/or practices

REGIS-AG's expected results are tied to the project's main objectives:

- Strengthened vertical and horizontal value chain linkages and relationships in selected value chains
- Strengthened input supply and other supporting services and improved smallholder and agro-pastoralist access to these interconnected markets
- Increased innovation and private-sector investment
- Improved environment for local and regional private sector investment

REGIS-AG's main activities include:

- Organizing cowpea, poultry and small ruminant market fairs
- Developing marketing platforms and promoting competitiveness in end markets
- Promoting women's economic empowerment and expanded role in the market
- Creating market linkage networks for producer groups
- Strengthening coordination of stakeholders in the three value chains
- Training agro-dealers in business management and input application
- Training project participants, particularly women, in functional literacy
- Training veterinary workers and vaccinators in business management and service provision

REGIS-ER Background

Following repeated large-scale humanitarian emergencies in the Sahel, USAID recognized that continuing to treat these recurrent crises as acute emergencies is extremely costly and does not effectively address their underlying causes. Thus, USAID's RISE initiative has realigned existing and new humanitarian and development assistance efforts to strengthen resilience in agro-pastoral and marginal agriculture livelihood zones of the Sahel. USAID will reduce chronic vulnerability by increasing economic well-being, strengthening institutions and governance, and improving health and nutrition status. REGIS-ER is RISE's flagship multi-sectoral resilience project that works to end the vicious cycle of crisis and help the Sahel's most vulnerable populations stay firmly on the path to development.

REGIS-ER addresses the root causes of chronic vulnerability by increasing the capacity of households, villages and systems to adapt to and recover from shocks and stresses. REGIS-ER integrates sustainable livelihoods, natural resource management, governance and health and nutrition activities in collaboration with local communities.

REGIS-ER's expected results are tied to the project's three main objectives:

- Sustainable livelihoods: diversified economic opportunities, intensified climate-smart agricultural and animal production and marketing, increased access to financial services

- Enhanced governance: strengthened natural resource management, disaster risk management, conflict prevention and management, increased coordination between regional and local governance structures
- Improved health and nutrition: increased access to potable water, improved health and nutrition practices

REGIS-ER's main activities include:

- Creating a network of community-based solution providers to promote local entrepreneurship while increasing access to key products, services and information

- Improving soil fertility and crop production through conservation farming, farmer-managed natural regeneration, bio-reclamation of degraded land, anti-erosion/water conservation structures and small-scale irrigation
- Promoting livestock as a means to increase revenue, improve nutrition and build household assets
- Diversifying diets through home and community gardens and nutrition education
- Increasing access to credit and savings through village-based saving groups, access to micro-finance institutions and warrantage
- Enabling effective and inclusive natural resource management through legally recognized land use plans and local conventions
- Strengthening community-based early warning systems and response capacities
- Preventing conflict by strengthening local land tenure structures, demarcating pastoral corridors and obtaining legal rights to land use
- Increasing access to potable water sources by constructing/rehabilitating boreholes, strengthening community water management and marketing water treatment systems
- Enabling key health and nutrition practices through mother-to-mother groups, husband schools, safe space for adolescent girls and community quality improvement teams
- Mobilizing communities to attain open defecation-free status through community-led total sanitation

SECTION 3: METHODOLOGY AND ANALYSIS OF PESTICIDES REGISTERED BY INSAH FOR WEST AFRICAN COUNTRIES, INCLUDING BURKINA FASO AND NIGER

METHODOLOGY

As noted in the Introduction and Executive Summary, above, this PERSUAP is a re-write of a recently-rejected 2017 PERSUAP written for both REGIS projects by a project staff with a background and expertise in forestry. During June 2017, field visits were made with project technical staff to project-supported farms and farmers, private sector pesticide wholesalers and retailers, NGOs (non-governmental organizations), exporters of high-value crops, government officials, especially in the Ministries of Agriculture (MOA) and project staff. In Niger, sites were visited in Niamey as well as in and around project sites near Maradi. In Burkina Faso, visits were made in Ouagadougou as well as in and around project sites near Kaya and Fada N'gourma.

REGIS projects technical staff were asked to make lists of all food security and high-value vegetable, fruit, forage and animal feed crops, stored grains, poultry, and livestock targeted for assistance. Then they were asked to compile preliminary lists of primary pests, diseases and weeds of each crop and animal produced. This list was further elaborated with information from farmers, pesticide business owners, MOAs, other parts of government and donors, high-value crop exporters, and others visited. Schedules of field visits are compiled and summarized in Annex 8.

For productivity and efficiency, this PERSUAP leverages as many parts of recent PERSUAPs written to cover Burkina Faso and Niger, including the above-referenced rejected PERSUAP as well as another PERSUAP written for one of the Niger Development Food Assistance Programs (DFAPs) and updated in 2015, while correcting as many errors as possible in those documents, and updating the information. For the same pests and diseases, it uses information from other PERSUAPs with the exact same pests and diseases.

This document had to stay within a limit on level of effort (LOE) required for researching over 30 crops and livestock, and over 300 pests, diseases and weeds. It also had to meet a USAID DCHA-mandate that the list of pesticide AIs should be limited to no more than 30, while at the same time, the team dealt with the conundrum of not having sufficient alternative classes of pesticides and AIs for rotation to avoid development of pesticide resistance, another DCHA mandate.

These limitations obliged the PERSUAP team to offer creative pesticide acceptance and rejection decisions. In addition to rejecting pesticide AIs not registered by EPA, RUP, Class I, known carcinogens and known water pollutants, the best way to cut the list of AIs down further to DCHA's mandate was to reject pesticides registered by INSAH for commercial agriculture sectors, namely for use only on cotton, rice and sugar cane, but to expand the uses of remaining INSAH-registered pesticides to include crops listed on pesticide labels and known to be used by farmers, regardless of INSAH crop use authorization, because it made sense to do so for the same registered uses as those found in the USA.

PESTICIDES ANALYSIS

Pesticides registration for West African francophone countries is done regionally through INSAH. The most recent (May 2017) INSAH list of approved (homologized) pesticides is found on the following website:
http://www.insah.org/doc/pdf/liste_globale_pesticides_autorises_par_CSP_vers_Mai_2017.pdf. This list primarily serves commercial agricultural interests in West Africa.

Most pesticides registered or homologized by INSAH are authorized for use on high-value cash crops, primarily cotton, followed closely by sugar cane and rice (none of these are REGIS target crops), followed by tomatoes, maize, groundnuts, mangoes and onions. Some are registered for use on ‘cereals’ which can include sorghum and millet. Few are registered specifically for use on 'garden crops' ('cultures', or maraîchage in French), other vegetables and fruits, due to lack of economic importance.

Despite INSAH's "authorized uses" for each pesticide, the labels on the bottles these pesticides are sold in contain lists of other crops and pests that each can be used on, and REGIS farmers use them on these other crops and pests. For this reason, this PERSUAP approves use on these additional crops. Further, a certain amount of technical decision-making latitude, built into and afforded by Regulation 216's "same or similar use" language, is also brought to bear on the uses for which each pesticide is registered, particularly where fruits and vegetables are concerned, since they are not well covered by INSAH's focus on more valuable commercial crops. This document uses both English and French spellings of each AI, interchangeably.

NATURAL ARTISANAL PESTICIDES

Few natural pesticide products are registered by INSAH, but farmers and small-scale operations produce their own artisanal concoctions that work well as repellents and disease suppressants. These include extracts from neem tree seed, both the combined neem oil fraction, useful against plant diseases and some small pests, and the aqueous fraction containing azadirachtins, which are both antifeedants or repellents and biotoxins. Additionally, extracts of garlic, chili, onion, citrus skin essential oils and fire ashes are produced as repellents. One group based in Fada-N'gourma, Burkina Faso, Bioprotect, produces these extracts on a small scale for sale to farmers, and labels them as "biostimulants" instead of biopesticides. Often, these extracts can be used to push pest and disease organism numbers and damage down sufficiently such that they do not require further treatment with synthetic pesticides.

FUMIGANTS

INSAH only registers one fumigant, Aladin, containing the Active Ingredient (AI), aluminum phosphide (phosphure d’aluminium), in pellet/tablet form, for use on stored grain. The gas produced by these pellets/tablets, phosphine, is highly toxic, requiring the use of specialized and expensive equipment and training, which smallholder farmers do not possess. For this reason, smallholder farmers should be discouraged from buying, and not allowed to use, this chemical for on-farm/home grain storage.

FUNGICIDES

INSAH registers products containing 15 fungicide AIs, mostly for use on cotton and tomatoes, followed, in order of importance by groundnut, rice, mango and garden crops. Two of those are not registered by EPA and some are registered specifically for use on cotton or rice, neither of which are REGIS target crops; thus, they are rejected for use on REGIS crops. None of the fungicides are restricted use pesticides (RUPs).

Six of the 15 AIs are formulated and registered for use as seed treatments, primarily on cereals. All but one seed treatment product should be done only by professional services with PPE-protected employees who understand the risks. The issue with these other fungicide seed treatments is that they contain thiram in powdered/dust form, which if inhaled, can be quite toxic to humans.

Unfortunately, INSAH's registered copper fungicide/bactericide products are too high a concentration and thus too toxic for project smallholder farmers to safely use. EPA rates most of these as Class I acute toxicity. Copper products must also be used with care, to avoid over- or repeat-applications, which can increase soil copper toxicity. For these reasons, neither of the copper-containing products are approved for REGIS promotion to smallholder farmers. If, in the future, professional spray services with proper PPE and training are formed, Class I chemicals could be used by them. And, this PERSUAP could be amended to permit such use.

Two natural or biological fungicides containing non-toxic *Aspergillus flavus* fungal strains can be used to compete with and reduce the natural levels of aflatoxin-producing *A. flavus* strains found in the field on maize and groundnuts, thus reducing aflatoxin contamination. Strains of this fungus are very location-specific, so the ones produced for, and registered in, the American market may be different than those useful for and registered in West Africa. Thus, decision-making latitude is again used to approve West African strains different from, but sufficiently like, those registered by EPA.

Nine approved fungicide AIs are contained in the Executive Summary, as well as in Annex 4, which provides information on chemical class for rotating, acute and chronic toxicity, groundwater pollution potential and ecotoxicity for each pesticide AI.

Please note, rotation strategy by mode of action (MOA), as descriebd in Page 16.

SEED TREATMENT PRODUCTS

Almost all vegetable seed found for sale in farm stores contains treatments of fungicides and sometimes in combination with an insecticide, not all of which are INSAH-registered. The most common chemicals found on factory-treated vegetable seed were thiram, iprodione, thiophanate-methyl and insecticide imidacloprid, all of which are EPA-registered AIs. Some maize seed is treated as well with insecticide AI thiamethoxam. INSAH only registers pesticides for treatment or use, not those that enter member countries already on treated seed.

Generally, PERSUAPs do not permit seed treatment by smallholder farmers due to lack of technical skill, proper bulk mixing equipment and know-how, and PPE. However, the one seed treatment approved by this PERSUAP, Apron Star 42 WS, which contains a mixture of two fungicides and an insecticide is produced, formulated and packaged in single-use sachets by Syngenta specifically for smallholder farmer use, with instructions for use on an easily measured quantity of seed.

HERBICIDES

INSAH registers products containing 47 herbicide/plant growth regulator (PGR) AIs, mostly for use on cotton and rice, followed, in order of importance by maize, sugar-cane, onions, groundnuts, garden crops and cereals. Fifteen of these AIs are not registered by EPA (listed in Annex 9) and none are contained in RUPs.

Nine of the herbicide AIs are registered only for use on rice, seven are registered solely for use on sugar cane, three are registered solely for use on cotton and one is registered for use on sugar cane and cotton, but no other crops. Since cotton, sugar cane and rice are not supported by USAID or REGIS, these AIs are rejected for project promotion or use.

Nine AIs are registered only for use on maize, two for use on either maize and rice, and three are registered for use on onions. Numerous products containing glyphosate are registered for burning down vegetation prior to planting maize, but some are also registered for general use.

INSECTICIDES

INSAH registers products containing 58 insecticide AIs, 14 of which are synthetic pyrethroids registered for use in the health sector against mosquitoes and/or general residential use against mosquitoes and household pests. Pesticides registered solely for use against mosquitoes and/or household pests are rejected for use in the agriculture sector (Annex 9). Most of the remaining synthetic pyrethroids are registered for use in the cotton sector in mixtures with systemic neonicotinoids. The EPA has designated most synthetic pyrethroid products as RUPs, due to very high risk to aquatic organisms should the pesticide enter surface water. Three insecticides are registered for use against locust plagues. All these are also rejected for promotion or use by REGIS.

One AI, abamectin, is approved in four products for use against mites. Four pesticide products are registered for use on stored grain. Most of the rest of the insecticide AIs, almost half, are registered for use on cotton (26, all rejected since cotton is not a project crop), followed by tomatoes (15), mangoes (6), garden vegetables, cabbage, peppers, and rice. None are registered specifically for use on cereals, even though some of the product labels found during field pesticide shop visits show other uses, including use on cereals.

MOLLUSCICIDES

INSAH registers no products containing molluscicides.

NEMATICIDES

INSAH registers nematicides with only 2 AIs, both of which are rejected for support or use due to being highly toxic RUPs. A primarily fungicide AI, fluopyram, is also registered by INSAH as a protectant against damage caused by certain plant pathogenic nematodes.

RODENTICIDES

INSAH registers one rodenticide with one AI, brodifacoum.

AVICIDES (KILL BIRDS)

INSAH registers no products containing avicides.

PEST OUTBREAKS AND EMERGENCIES

Burkina Faso and Niger have always been subjected to outbreaks of locust and grasshopper outbreaks. Generally, donated and government-managed resources and pesticides are brought to bear to manage such outbreaks. More recently, pests such as the tomato destroyer moth/larva, *Tuta absoluta*, have become a serious pest in the region. And, presently, the Fall Armyworm, *Spodoptera frugiperda*, until now an American pest, has invaded and is moving across the Sahel, and as of late 2017, has invaded most parts of southern Burkina Faso and Niger. And, Huang Long Bing (HLB) citrus 'greening disease' moved to South Africa from Asia, and spread throughout Africa since.

FAKE, ADULTURED AND COUNTERFEIT PESTICIDES

CropLife International (CLI), the plant science and pesticide industry advocacy group (https://croplife.org/crop-protection/anti-counterfeiting) notes that:

“Counterfeiting is a dangerous and growing problem for all industries, including the plant science industry. Counterfeiting of plant science products brings to bear a range of negative effects for the industry, farmers and the environment.

These negative impacts of counterfeit pesticides include:

- economic ruin for the farmer; potential loss of harvest due to use of an ineffective counterfeit
- discouragement to honest local entrepreneurs from investing in legitimate product development
- hampering of investment, employment, technology transfer and tax revenues

- the potential harm to the environment as counterfeits are not tested for safety (whereas legal products are extensively tested before they are authorized and fulfill strict requirements)
- risk that buyers of export crops will boycott crops treated with counterfeit pesticides thus posing an economic risk to countries relying on export crops
- risks of human, animal and environmental poisoning

The effect of counterfeiting is that it could eliminate the incentive for plant science companies to continue to invest considerable time and money in the development of new technologies that can help assure global food security and alleviate hunger and poverty. Furthermore, counterfeit pesticides risk the health and safety of workers and farmers."

The European Crop Protection Association (ECPA) goes even further, to note that:

> ″Counterfeit and illegal pesticides are being produced, marketed and sold by criminals around the world. Improved access to technology and legislative loopholes facilitates the trade of counterfeit and illegal products. This is serious organized crime.
>
> Counterfeit and illegal pesticides are untested and unauthorized. They can result in yield losses for farmers, and potentially pose risks to human health and the environment. ECPA works with authorities and supports communication activities to raise awareness and help bring an end to the trade in counterfeit and illegal pesticides. Counterfeit and illegal pesticides arrive on the European market primarily via smuggling or under the cover of illegal parallel imports."

Eighty-six percent of counterfeit goods caught by European customs originated in China. Four percent came from Malaysia and two percent came from United Arab Emirates.

Newsfood.com reported that:

> "In June 2008, regional police in Russia uncovered a major pesticide-counterfeiting facility. Police raided premises near the city of Kursk, close to the Ukraine border, where around 100 tons of counterfeit and illegal pesticide products were found with an estimated market value of over $1 million euros. Most of the products were illegal copies of patented and branded products from major legitimate manufacturers pre-packed into containers ready for commercial sale.
>
> Adjacent to the warehouse, the police uncovered equipment designed to apply labels and stickers to the bottles, as well as other packaging equipment. Initial examination of the symbols on the seized product containers indicated that the products were manufactured in China. There are also indications that the transport routes to Kursk may be different for differing consignments, with some arriving by sea and others by road and some possibly running through an EU port. Many likely end up in, or passing through, Ukraine to other European destinations. This raid followed a major seizure in late 2006

at the port of Odessa, Ukraine where over 500 tons of counterfeit and illegal pesticides were seized.

As recently as December 2015, 190 tons of counterfeit pesticides were seized by Europol in seven countries over several days (https://www.europol.europa.eu/content/huge-seizures-190-tonnes- counterfeit-pesticides). This operation focused on the marketing and sale of counterfeit pesticides, including infringements of intellectual property rights such as trademarks, patents and copyright,

as well as targeting the illegal trade of pesticides. CLI and ECPA assisted the operation with data about counterfeits.

Types of counterfeit and illegal pesticides include fakes, adultured, counterfeits and illegal parallel imports. Fakes can contain anything from water or talc to diluted (adultured) and outdated or

obsolete pesticide stocks, including banned or restricted chemicals to enhance activity. Some fakes sometimes contain an illegal and untested copies of the generic (off-patent) and proprietary active substance. Fake products are often sold in simple plain bottles with minimal labeling describing their use, and no health or environmental precautions.

Counterfeits are sophisticated pirated copies of legitimate, branded products, and usually have high-quality labeling and packaging that mimics that of legitimate brands. Counterfeits are often difficult even for experts to distinguish from legitimate products. Most counterfeits will contain a copy of the original active ingredient, but at an unknown quantity and quality, often with highly toxic manufacturing impurities that harm human health.

Illegal parallel imports are generic copies of legitimate, parallel-traded generic products. These generic products have been repackaged and sold as brand-name products, with the same or a very similar product name.

- Challenges of quantifying the problem.
- There are insufficient funds for testing, enforcement, seizures and prosecution.
- National enforcement is weak.
- Inadequate judicial frameworks and penalties.

Potential solutions that should be promoted by all USAID FFP (Food for Peace) and agriculture programs:

- Upgrade MOA or other analytical laboratories to be able to test for AIs and byproducts
- Randomly test samples of all products imported to determine amount and quality of AIs
- Do additional samples of suspect products
- If products fail the test, immediately impound and seize them from markets
- Use CLI's database of counterfeits to identify illegal pesticides
- Encourage the local government customs officials to seize illegal pesticides

- Encourage government officials to prosecute counterfeiters
- Promotion of products from reputable stores or distributors
- Train beneficiaries to avoid bargains from unknown suppliers
- Product labels must be in the national language/s
- Avoid promoting non-registered products made in China or Malaysia
- Ask for a receipt that includes accurate purchase details
- Only purchase legitimate, registered pesticides
- If information relating to the sale of illegal products is found, contact the relevant national authority.

FUTURE PESTICIDE QUALITY VERIFICATION SYSTEMS

Two companies currently focus on detecting counterfeit pharmaceuticals, mPedigree (http://mpedigree.net/) and Sproxil (https://www.sproxil.com/about-us/). Both aim—in the

future—to be able to detect counterfeit pesticides as well, and merit following and perhaps using for this purpose. One drawback of using these applications, is that they market to and favor larger international producers who have sufficient financial resources, and could block legitimate smaller companies (https://cdippel.wordpress.com/2012/09/13/counter-counterfeiting/) producing legal, off-patent generic pesticides.

CERTAINTY WITH PESTICIDE QUALITY

In an ideal world, our REGIS team and project would like to be able to identify all counterfeit chemicals for farmers, but without analytical capability by and funding for the MOA, or a regional International Standards Organization (ISO)-certified laboratory sub-contracted and paid to randomly check imported products for AI presence and concentration, as well as to check for other chemical contaminants or additions, this will continue to be challenging, if not impossible. None of these conditions exist. Kindly see http://www-pub.iaea.org/MTCD/Publications/PDF/te_1612_web.pdf. If USAID or DCHA wishes to eliminate all unsafe products, USAID must provide a special fund and operations—and accept full legal responsibility—for the testing and publishing results of such pesticide tests. Annex 5 provides additional information on how to improve quality assurance with pesticide choices.

SECTION 4: PESTICIDE SYSTEM RISKS FOUND IN BURKINA FASO AND NIGER

During field visits in June of 2017, risks were identified in the agriculture pesticide use sector in Niger and Burkina Faso. Those risks are compiled in the table below, with recommendations for reducing these risks.

Problems, constraints or risks in Burkina Faso and Niger pesticide cycle of use	Recommendations for government MOAs, MOEs and donors
Banned POPs chemical endosulfan still enters both countries via informal channels from the cotton sector	Sensitize government officials about the threats to Niger and Burkina Faso' trade potential, and do training
Lower quality, illegal & pirated Chinese pesticides present	Do repeated training on pesticide quality choices
Funds for analyzing and monitoring pesticides and residues is insufficient	Donors and produce exporters and authorities combine resources for testing
Limited resources for pesticide regulations enforcement	Taxes need to be levied from agriculture sector for enforcement
Limited resources for extension	Do demonstration farms and field days on IPM and SPU
Lack of pesticide toxicity awareness by farmers	Do repeated training on pesticide choice, risks and how to reduce risks
Limited farmer knowledge of pest Identification (ID) & IPM tools	Increase knowledge, do repeated training on IPM, including pest and disease identification
Over- and under-applications of pesticides	Do repeated training on calibration & application
Illiterate farmers cannot read pesticide labels	Do repeated training on pesticide cautions and interpretation of pictograms
Wrong pesticide applied for pest or disease	Do repeated training on pesticide choices

Problems, constraints or risks in Burkina Faso and Niger pesticide cycle of use	Recommendations for government MOAs, MOEs and donors
Regional INSAH regulations and pesticide registrations primarily serve the commercial agriculture sectors Proximity to major cotton, tobacco and rice production & chemicals	Encourage INSAH to register and authorize pesticides for non-commercial vegetable and fruit crops Diversify production, knowledge & input demand
Pesticide shops with limited safety equipment (PPE) on hand	Train shop-keepers and farmers on proper pesticide safety and subsidize PPE
Pesticides subdivided into un-labeled containers, like empty water bottles, and sold	Train shop-keepers and farmers on proper pesticide safety
Pesticides stored in the home, often in un-labeled containers Pesticide mixing with bare hands and little use of PPE by pesticide appliers	Do repeated training on proper pesticide storage Do training on proper mixing and PPE to use; provide PPE
Pesticides applied at wrong time of day and with winds too high, and rain	Do repeated training on application times risks
Back-pack sprayers leak onto spray personnel	Do repeated training on sprayer maintenance
Products with endosulfan, paraquat and carbofuran still available (but decreasing) in bazaars and stores, and used	Do repeated training on pesticide choice & quality
Highly toxic aluminum phosphide present in input stores and sometimes used by smallholder farmers	Do repeated training on pesticide choice & quality
Improper disposal of unused pesticides & empty pesticide containers (EPCs)	Do repeated training on proper disposal of unused pesticides and EPCs

Positive factors that reduce risks from pesticides in Burkina Faso and Niger

- INSAH helps regulate pesticide use and does pesticide registration for francophone countries including Burkina Faso and Niger.
- The international ban on pesticides containing endosulfan is slowly being implemented, reducing the amounts available and encountered in the field.
- Stockpiles of large quantities of old locust plague pesticides are being disposed of, with donor help.
- The number and quantity of highly toxic Class I and banned chemicals has decreased compared with just 10 years ago (personal observation), and many less toxic (Classes III and IV/U) products are being registered and used by farmers.
- Farmers have been organized into "Village Brigades" with pesticide backpack and ULV (ultra-low volume) sprayers, PPE and training on IPM and SPU, which helps them manage pest and disease outbreaks with reduced risks.
- Availability of biologically-derived, effective and approved products like non-aflatoxin *Aspergillus flavus,* abamectine, BT/ *Bacillus thuringiensis* var. Kurstaki, kaolin clay/aluminum silicate, spinosad, *Tagetes* African Marigold oil and thyme oil.
- Presence of NGOs like Bioprotect and entrepreneurial farmers making extracts of neem tree seed, garlic, chili pepper, onion and citrus skins for use as insect, mite and disease organism reducers.
- The fact that Niger and Burkina Faso must follow European standard and certification (S&C) systems to reach European markets with high-value produce. Many farms oriented for export are becoming more organized following S&C systems like GlobalGAP, Organic, Fair Trade and others, which inevitably contain recommended IPM measures that work as well as reduced-risk pesticide products and SPU requirements.
- The increasing availability and use of small, single-use sachets and smaller bottles of pesticides (as opposed to one and five liter bottles) with labels containing important and potentially life-saving information (in local languages) that are marketed by the formal pesticide importer/distributor sector. These small quantities and labels help resolve on-farm pesticide quantity storage, illegal subdividing and use issues.

Conclusion: There remain some issues with pesticides that can increase risks for errors to occur, and thus the risks that farmers, laborers, farm family members, their environment, and even international consumers may be exposed. Thus, the pesticide risk profile for Niger and Burkina Faso is higher than might be encountered in some more developed countries, but some positive developments noted above are gradually reducing these risks.

SECTION 5: PESTICIDE EVALUATION REPORT (PER)

This part of CNFA's and NCBA-CLUSA's Burkina Faso and Niger REGIS PERSUAP, the PER (Pesticide Evaluation Report), addresses pesticide choices registered, imported and available for the smallholder farmer sector—REGIS's target—based upon environmental and human health issues, formulations and uses, alternate options, IPM, biodiversity, conservation, training, PPE options, and monitoring and mitigation recommendations according to the twelve Regulation 216.3(b)(1) Pesticide Procedures Factors, outlined to the right in blue and analyzed below.

Importantly, this analysis rejects the many pesticides registered and imported primarily for the commercial agriculture sectors, since the chances that smallholder farmers would have access to these, let alone actually be able to afford them, are low.

Reg. 216.3(b)(1)(i) stipulates: "When a project includes assistance for procurement or use, or both, of pesticides registered for the same or similar uses by USEPA without restriction, the IEE for the project shall include a separate section evaluating the economic, social and environmental risks and benefits of the planned pesticide use to determine whether the use may result in significant environmental impact. Factors to be considered in such an evaluation shall include, but not be limited to the following:" (see box, right)

THE 12 PESTICIDE FACTORS

Factor A. *USEPA Registration Status of the Proposed Pesticides*

Factor B. *Basis for Selection of Pesticides*

Factor C. *Extent to which the proposed pesticide use is, or could be, part of an IPM program*

Factor D. *Proposed method or methods of application, including the availability of application and safety equipment*

Factor E. *Any acute and long-term toxicological hazards, either human or environmental, associated with the proposed use, and measures available to minimize such hazards*

Factor F. *Effectiveness of the requested pesticide for the proposed use*

Factor G. *Compatibility of the proposed pesticide use with target and non-target ecosystems*

Factor H. *Conditions under which the pesticide is to be used, including climate, geography, hydrology, and soils*

Factor I. *Availability of other pesticides or non-chemical control methods*

Factor J. *Host country's ability to regulate or control the distribution, storage, use, and disposal of the requested pesticide*

Factor K. *Provision for training of users and applicators.*

Factor L. *Provision made for monitoring the use and effectiveness of each pesticide*

In Annex 1, this PERSUAP proposes preventive IPM tools and tactics available to be integrated with the pesticides evaluated by this PER, and to be recommended by extension services, REGIS field technical staff and other USAID projects. Annex 1 can be used as a pullout, stand-alone section that can be reproduced as necessary, and should be considered for field testing and adaptation, translation into the local language (French, the official language of Burkina Faso and Niger spoken by most smallholder farmers), lamination, and distribution to project field staff to help advise beneficiary farmers.

Annex 2 provides guidelines for making PMPs and Annex 3 provides a system for using IPM.

It would be ideal to find pesticides for every need that are EPA Class IV (the lowest) acute toxicity, have no chronic human health issues, no groundwater pollution issues and no ecotoxicity issues. Such pesticides do not exist. Most pesticides, including “natural” pesticides, have toxicity to at least one aquatic organism, or honeybees, or birds, and at a sufficiently high concentration, can kill people.

5.1 FACTOR A: USEPA REGISTRATION STATUS OF THE PROPOSED PESTICIDES

USAID project activities are effectively limited to promoting during training, recommending, buying, subsidizing, financing or permitting on demonstration farms, pesticides and seeds coated with pesticides containing AIs in products fully registered in 2017 by INSAH as well as in the US by the EPA for the same or similar uses, without restriction. Emphasis is placed on “similar use” because occasionally the crops or livestock and their pest species found overseas are not present in the US, and therefore pesticides may not be registered for the exact same use, but often are registered for the same or similar crops and livestock, pests, formulations, methods of application, and pest situations.

The USEPA classifies pesticides according to actual toxicity of the formulated products, taking formulation types and concentrations into account, thus generally making the formulated product less toxic than the concentrated or technical active ingredients alone would be. This method of classifying acute toxicity is accurate and representative of actual risks encountered in the field.

It is important to note that all emerging market countries in which USAID works, as well as the labels on the pesticides sold in them, use the WHO acute toxicity classification system, not the EPA system. The USA (and by extension Regulation 216) is the only country to use the EPA acute toxicity classification system.

In the USA, some specific commercial pesticide products are labeled as RUPs due to inordinate risks, usually under specific circumstances of use, such as formulation, concentration or commodity. However, for each AI, which may be present in several RUP products, there are generally additional or other products, formulations and uses—with the exact same AI—that do not pose the same risks and are thus labeled or determined to be General Use Pesticides (GUPs)—that is—not a RUP. Ergo, for each AI, there may be RUP and General Use Pesticide, GUP (or non- RUP) products depending upon risks they do or do not pose.

INSAH registers pesticides annually, primarily for the health and commercial agriculture sectors, which require and can afford them. This list is provided as a poorly scanned pdf file on INSAH's website: http://www.insah.org/index.cfm?menuID=2&sb=02&pan=5. Unfortunately, INSAH does not provide this information in clean Word or Excel files, which would be much easier to search than a low-quality pdf file.

To research INSAH-approved pesticide AIs for EPA compliance, toxicity and ecotoxicity, the following websites were extensively used by this study, with follow-ups on EPA websites for questions or concerns: http://www.pesticideinfo.org; http://sitem.herts.ac.uk/aeru/ppdb/en/atoz.htm; https://iaspub.epa.gov/apex/pesticides/f?p=PPLS:1.

As requested by REGIS, this PERSUAP evaluates all the pesticide AIs and products registered by INSAH as of May 2017, so that REGIS can more easily reject those not suitable, and recommend approved pesticides for use on crops/livestock/poultry produced by their smallholder beneficiary farmers, as desired. It also analyzes, as information exists, extracts of local plants known to be used by farmers.

The pesticide AIs that passed this Factor A analysis are listed in the Executive Summary. The matrices in Annex 9 provide the names of the pesticide AIs that failed this Factor A analysis, with the reason they are rejected by this PERSUAP for provision for or promotion to smallholder farmers.

Fake, Adultured and Counterfeit Pesticides. It is important to note that, like most African Countries, Burkina Faso and Niger farmers receive shipments of fake (without active ingredients), adultered (diluted active ingredients) and counterfeit (copies of brand name pesticides, but without quality controls on ingredients and formulation, and often with toxic hazardous manufacturing byproducts) pesticides. Major imports of pesticides into Burkina Faso and Niger come from both Ghana and Nigeria, sources of fake, adultured and re-packaged pesticides, and China—known internationally as a primary source of counterfeit pesticides. It is imperative that the REGIS program recognize this issue and address it during training of beneficiary farmers. Some recommendations for doing this are included above, in Section 3, under Burkina Faso and Niger pesticide context, and in Annex 5.

PERSUAP TECHNICAL DECISIONS BASED UPON AN EVALUATION OF LOCAL RISKS, EPA'S AND REGULATION 216'S INTENT, AND COMMON SENSE

This PERSUAP is tasked with evaluating and making risk-reduction decisions, first based upon an understanding of the local milieu, smallholder farmer needs, and the level of risk present (which can only be determined by visiting Burkina Faso and Niger, government institutions, pesticide importers and retailers and smallholder farmers), second by understanding and interpreting EPA's and Regulation 216's intentions on risk reduction, and third, by common sense reasoning and arguments. This PERSUAP study uses each of these. In addition to rejecting unregistered and restricted pesticides, the PERSUAP team used the technical interpretation liberties granted by Regulation 216's "same or similar use" language to make decisions based upon additional technical and social information collected, such as differences in concentration, formulation, potential versus known carcinogenicity, exceptionally smaller scale of Burkina Faso and Niger smallholder farmer pesticide use needs and patterns versus use patterns experienced in the USA, and potential food security risks of not approving certain chemicals which fall into this gray area.

Using this reasoning, one pair of chemicals analyzed herein falls into this gray area, open for interpretation. The insecticide AI pirimiphos-methyl, an organophosphate chemical most commonly available in dusting powder (DP) formulations, is used either alone or in mixtures with a synthetic pyrethroid like permethrin, as a treatment on, or admixture to, bags of stored whole grains (not grain flours). These treatments protect the grain from pests like very small beetles, weevils, and moth larvae that feed on and in grain and on grain dust. These pesticides are ubiquitous in Africa in very small affordable quantities and are used by many smallholder farmers, as well as in larger quantities by highly-skilled warehouse grain storage pest management companies.

In the USA, the EPA registers only one stored grain protection product with the exact same AI and name, Actellic, but with a pirimiphos-methyl concentration of 57% and accompanying acute toxicity classification of Class I, the most toxic. Furthermore, American grain storage warehouses have a plethora of additional and less toxic options and chemicals to choose from for pest control.

In Burkina Faso and Niger, as in most of Africa, however, Actellic is one of the few options available and affordable, and it is usually formulated with a much lower concentration of the AI pirimiphos-methyl (also spelled pyrimiphos-méthyl), in Burkina Faso and Niger at 10% to 20%, or in combinations with a synthetic pyrethroid, thus rendering a much lower class of acute toxicity listed on the label, WHO Class III, which makes sense for smallholder farmers/users with different needs, fewer options, and a relatively higher risk environment. Rejecting its use by smallholder farmers because of EPA's toxicity class for a product with the same name, but much higher concentration, would increase risks of grain losses for these farmers. Instead, our REGIS PERSUAP team approves it, because of the lower concentration, lower acute toxicity class, small bag size, availability, affordability and needs of our smallholder beneficiary farmers.

COMPLIANCE REQUIREMENTS

- REGIS program must not promote, finance and use on demonstration farms, pesticides not registered by EPA for same or similar use or those classified by EPA as RUP products (pesticide AIs and products rejected by this PERSUAP listed in Annex 9).
- REGIS program shall obtain and retain copies of the MSDSs for each pesticide that their beneficiary farmers use frequently.
- REGIS program shall promote the use of brand-name pesticides of known quality, with complete label safety information, and shall caution smallholder farmer beneficiaries on use of pesticides imported from China, Ghana and Nigeria and not meeting local legislated standards.
- If REGIS wishes to recommend or use on demonstration farms any pesticides not registered by EPA or categorized by EPA as a RUP product, then a full Scoping Study and EA must be done and approved by the BEO.

5.2 FACTOR B: BASIS FOR SELECTION OF PESTICIDES

The basis for the selection of pesticides is made by most farmers when they buy vegetable seeds already treated with pesticide coatings; the decision is made for them. Most of these seeds are also improved hybrid varieties with resistance to pests and diseases as well as certified as clean from seed-borne disease organisms, a triple benefit requiring little extension work and technical know-how to use.

Most smallholder farmers in Burkina Faso and Niger cannot afford and do not use a range of synthetic pesticides, unless they work for Village Brigades (see above). Those few that do use pesticides choose them based primarily upon the advice of neighbors, retailers, donors, and occasionally extension agents. They also use products in quantities they desire and can afford to make decisions when buying pesticides from retail shops.

Commercial farmers, on the other hand, have more resources and purchase both quality generic as well as newer (and more expensive) products from more reputable regional providers: Arysta Life Sciences/SAPHYTO (African Society of Phytosanitary Products and Insecticides), with a formulation plant in Bobo-Dioulasso, Burkina Faso and offices in Ouagadougou, SAPHYTO-AGRIMEX, headquartered in Niamey, with a franchise Maradi, and LDC (Louis Dreyfus Commodities), a Dutch company; as well as multinationals Bayer, BASF, Dupont, Dow, Syngenta, Machteshim Agan and Monsanto. Generally, large commercial producers purchase their pesticides directly from importers/wholesalers/distributors, in bulk, to save money, often bypassing smaller retail shops in the countryside outside of Niamey and Ouagadougou.

Retail stores in Niamey and Ouagadougou have available small 100ml bottles of pesticides, as well as 250ml sizes, which are more affordable to smallholder farmers than larger sizes (500ml, 1 liter). Smallholder farmers also have access to smaller (25-250g) foil-packs of powder formulations of fungicides containing mancozeb, and 50g of insecticides containing pirimiphos-methyl used on stored grain. These smaller quantities reduce the need for storing leftover quantities of pesticides in the home where children might be exposed. And, they are affordable for smallholders who may not require an entire liter of a pesticide on relatively small hectarage. Some retail stores in Niamey and Ouagadougou also had one liter bottles of pesticides for sale.

For selection of pesticides, see Annex 1, which shows the recommended uses, crops and pests for each pesticide approved under Factor A, as well as dosage and other useful information. The REGIS PERSUAP team found very little evidence of pesticide sub-packaging being done by retail stores.

Recommendations:

- In conjunction with providing training on preventive and curative IPM tools and tactics for each production constraint, REGIS shall provide training to smallholder farmers on how to choose quality pesticides for specific uses, in the correct quantities and packages with labels.
- REGIS may also provide training to retail pesticide store owners on proper pesticide storage, security, signage, first aid, cleanup and sales practices.

- REGIS program shall provide training to encourage farmers to use products with lower human and ecological toxicities if there is a choice among pesticide products and AIs, for any one production constraint.
- REGIS will raise awareness of the smallholders to the dangers of pesticides.
- REGIS Program will train the smallholder farmers to recognize signs, symptoms and first aid to assist the intoxicated persons.

5.3 FACTOR C: EXTENT TO WHICH THE PROPOSED PESTICIDE USE IS, OR COULD BE, PART OF AN IPM PROGRAM

Burkina Faso and Niger REGIS smallholder farmers use intercropping and mixed cropping practices, which reduce overall pest and disease pressure on their crops. They also use hand hoeing to remove weeds. And, some make and use their own plant extracts to repel pests and reduce the incidence of diseases. Internationally, IITA (the International Institute for Tropical Agriculture, headquartered in Nigeria) has produced and introduced biological controls for cassava pests across the region, including in Burkina Faso and Niger. Both countries have IPM units in their MOAs, and do research on preventive and non-synthetic chemical controls. They support use of artisanal plant extracts, live-trapping of rodents, testing and use of resistant varieties, seed certification, crop rotation, biological control of cereal pest eggs by rearing and release of *Trichogramma* wasps, biological control of millet head miner by rearing and release of *Habrobracon hebetor* wasps, and others. REGIS follows the IPM lead of both country MOAs.

REGIS provides and promotes the use of improved, resistant, clean and treated seed, the principal IPM tools for pest and disease management. The program also promotes the use of Good Agriculture Practices (GAPs) for each crop. Some of the older generic chemicals being illegally imported into Burkina Faso and Niger are, unfortunately, broad-spectrum and may have developed resistance issues in other countries where use has been higher, in addition to being relatively inexpensive and affordable, which means that they are not the optimal choice for IPM programs.

In any case, the approved pesticides (see list in Executive Summary) are recommended for use in Annex 1 and the resulting specialized commodity-pest IPM plans, but only if used wisely and judiciously, and as a last resort. Given the economic circumstances of most Burkina Faso and Niger smallholder farmers, the team considers it unlikely that farmers will be able to afford any but small quantities of pesticides. This is even more reason to learn and use all available preventive IPM tools.

REGIS agronomist field technical experts will need to ensure that farmers use as many preventive IPM practices as possible before deciding to use PERSUAP-approved synthetic chemicals, if they can afford them. Farmers who use pesticides will also need to be trained on how to determine proper dose and sprayer calibration, so as not to overdose, potentially killing important predators, parasites and parasitoids that attack and manage pest populations at tolerable levels. See Annex 1 to find approved pesticides recommended—as part of IPM plans—with detailed preventive tools and tactics for use to keep in check various pest and disease populations.

RECOMMENDATIONS:

- Preventive IPM tools and tactics for each commodity-pest combination (see Annex 1) should be taught to, recommended to and used by beneficiary farmers before the use of synthetic pesticides.
- REGIS should continue to assist with the provision of new IPM tools/tactics/technologies like resistant and certified disease-free and treated seed.
- REGIS to develop printed extension and IPM flyers, pheromone traps, pest prevention text messaging systems for farmer with cell phones.
- Burkina Faso and Niger would benefit from a national Pest Management Plan (PMP) containing preventive tools and tactics to help reduce pests/diseases of major crops and livestock, as well as curative pesticides if needed. Annex 1 provides a starting point for making such PMPs, embedded in larger, seasonal Good Agriculture Practice (GAP) plans. This adaptation of the information provided should be done by local experts who understand the cultural and social context, and know how to accomplish behavior change in their cultural milieu.

5.4 FACTOR D: PROPOSED METHOD OR METHODS OF APPLICATION, INCLUDING THE AVAILABILITY OF APPLICATION AND SAFETY EQUIPMENT

Most pesticide labels contain specific crop-pest usage and dosage information, even beyond that authorized by INSAH, and farmers use these crop-pest recommendations. Pesticides in the smallholder farmer garden (maraichère) sector are applied by small 3-5-liter hand-pumped sprayers, and sometimes by dipping a branch into the pesticide mix and shaking it onto the crop, not a best practice. Smallholder farmers with more resources purchase 16-liter plastic lever-pumped backpack sprayers with spray wand for use in larger fields. Cheap Chinese respirators with single carbon filters, respirators with paper filters and paper face masks, gloves and plastic goggles were found available in several of the retail stores visited in Niamey, Maradi, Ouagadougou, Kaya and Fada N'gourma.

This PERSUAP proposes to further form and use farmer cooperatives to pool resources to be able to purchase sprayers, share and maintain them for more routine pests and diseases. The same could be done with some PPE. Each cooperative could identify a member with a skill for dosing and calibration and have that person do all the spraying for a small fee, or a barter of services or goods. Village Brigade members that have sprayers and PPE could be used to control more routine pests and diseases, using MOA resources. Other than Village Brigade members, most the smallholder farmers that do occasionally use pesticides do not use PPE due to cost of the PPE, and lack of training on pesticide risks.

RECOMMENDATIONS/MANDATES:

- REGIS train farmers on proper use of PPE as well as pesticide dosing, sprayer calibration, use, maintenance and empty container disposal by rinsing, puncturing and disposal by burial, municipal waste, or recycling.
- Promote the concept of use of spray service providers hired both inside and outside of cooperatives.

- All farmer seed that requires treating with powdered fungicide AI thiram, which is too toxic for smallholder use, should be done by government-certified pest control company staff who have proper PPE, bulk seed treatment equipment, and technical training.

5.5 FACTOR E: ANY ACUTE AND LONG-TERM TOXICOLOGICAL HAZARDS, EITHER HUMAN OR ENVIRONMENTAL, ASSOCIATED WITH THE PROPOSED USE, AND MEASURES AVAILABLE TO MINIMIZE SUCH HAZARDS

This section of the PERSUAP examines the acute and chronic toxicological risks associated with the proposed pesticides. The pesticide AI analysis matrix in Annex 4 contains information on acute and chronic human and environmental toxicological risks for approved pesticide AIs. USAID-supported projects must be limited to EPA-registered pesticides, and decisions should be biased toward those pesticides with lower human and environmental risk profiles. Nevertheless, pesticides are poisons, and nearly all of them present acute and/or long-term toxicological hazards, especially if they are used incorrectly.

ISSUE: PESTICIDE ACTIVE INGREDIENTS ON POPS AND PIC LISTS

The Stockholm Convention on Persistent Organic Pollutants (POPs) and Rotterdam Convention's Prior Informed Consent (PIC) procedure which list banned and highly regulated toxic chemicals, respectively, were not known when Regulation 216 was written, so there is no language directly governing their use on USAID projects. Nevertheless, they present high risks to users and the environment, due to persistence and toxicity. It is thus prudent that they be discussed. The following websites contain current lists of all POPs and PIC chemicals: http://www.pops.int; http://www.pic.int.

RECOMMENDATIONS FOR MITIGATION

- Project staff shall ensure that none of these POPs or PIC pesticides, listed on the websites above should be used on REGIS projects beneficiary farms.

ISSUE: ACUTE TOXICITY

WHO Class Ia and Ib and EPA Class I pesticides are rejected for promotion to, or use by, project smallholder farmers. A few of the pesticides found in Burkina Faso and Niger contain active ingredients that are EPA or WHO Class II acute toxicity (based on mg/kg of body weight); with less toxic alternatives, including preventive tactics and tools (Annex 1), and some curative pesticide choices, including some that are WHO Classes III and U, for instance, also found in the Executive Summary and Annex 1. These should thus be promoted and used in place of Class II pesticides, when and where possible.

RECOMMENDATIONS FOR MITIGATION

Project staff shall ensure that beneficiaries do not use products that are WHO Class 1a or 1b, or products that are classified by EPA as Class I.

ISSUE: LOWER ACUTE TOXICITY PESTICIDES

Even EPA Class III and IV and WHO Class III and U pesticides will present acute and chronic human health and environmental risks (see decision matrix in Annex 4). In sufficiently high doses, any of them may kill or harm humans, or damage the environment and drinking water sources. Thus, pesticide safe use and handling training and practice are required for their use.

RECOMMENDATIONS FOR MITIGATION OF HUMAN TOXICOLOGICAL EXPOSURES

Most pesticide poisonings result from careless handling practices or from a lack of knowledge regarding the safer handling of pesticides. Pesticides can enter the body in four major ways: through the skin, the mouth, the nose, and the eyes.

Chapter 13 in the website resource http://pdf.usaid.gov/pdf_docs/PNADK154.pdf contains measures to reduce risks of exposure via oral, dermal, respiratory and eyes, as well as first aid measures. The time spent learning about safer procedures and how to use them is an investment in the health and safety of oneself, one's family, and others.

- Project field staff shall, during training, encourage demonstration farmers and beneficiaries with whom they work to not use POPs or PIC products or products containing very highly toxic active ingredients.
- Project field staff shall train beneficiaries and provide posters/flyers on SPU. For each group of farmers to be trained, staff shall identify the pesticides most likely to be used on their specific crops, and then identify the human health risks associated with each by using information on pesticide labels, in the attached Annex 4, and on MSDSs.
- Project field staff shall provide training on, and follow basic first aid for pesticide overexposure. To do this, they shall train managers and farmers on basic pesticide overexposure first aid, while following recommendations in http://pdf.usaid.gov/pdf_docs/PNADK154.pdf, as well as any special first aid information included on labels and MSDSs for commonly-used pesticides.

RECOMMENDATIONS FOR MITIGATION OF EXPOSURES TO ENVIRONMENTAL RESOURCES

Adhering to the following do's and don'ts can mitigate (reduce) ecotoxicological exposures and risks:

<u>Do's</u>

- Emphasize and use IPM practices in crop production
- Read and follow pesticide label instructions
- Choose the pesticide least toxic to fish, honeybees, birds, aquatic and other organisms (see Annex 4) and read the pesticide label

- Protect field borders, bodies of water and other non-crop habitats from pesticide exposure
- Completely cover pesticide granules with soil, especially spilled granules at the ends of rows
- Minimize chemical spray drift by using low-pressure sprays and nozzles that produce larger droplets, properly calibrating and maintaining spray equipment, and use a drift-control agent
- Properly dispose of empty pesticide containers (provide training on what this means locally)
- Maintain a 2.5 to 5 km buffer no-spray zone around national parks, water bodies or other protected areas
- Warn beekeepers of upcoming spray events so that they may cover or move their hives
- prevent access to fields for children and pregnant women at the time of spraying

Don’ts

- Do not spray over ponds, irrigation canals and drainage ditches
- Never wash equipment or containers in streams or irrigation canals where rinse water could enter ponds or streams
- Do not use pesticides with potential groundwater risks near drinking water sources, nor where the water table is less than 2 meters, and not on sandy soils with high water tables
- Do not apply pesticides in protected parks
- Do not spray when wind speeds are more than 13 kph
- Do not apply granular pesticides in fields known to be frequented by migratory waterfowl
- Do not apply insecticides from 10 am to 4 pm when honeybees are foraging; insecticides are best applied late in the day or evening when it is cool with no wind or rain, and when honeybees are finished foraging for the day.
- Do not spray in fallows that could be used as pasture

RISKS TO HUMANS

For each PERSUAP approved pesticide AI, the WHO (used in Burkina Faso and Niger) and EPA (used in the USA) acute human toxicity classifications, known chronic human toxicity, as well groundwater pollution potential (if known) are shown in Annex 4.

Pregnant women and children, as well as sick individuals, who are universally legislated to not be exposed to pesticides, should not spray or enter fields recently sprayed with chemicals that have chronic health risks such as endocrine disruption or reproductive and development toxin designations (see below).

Further, most INSAH-registered pesticides contain label and MSDS information on the safe Re-Entry Interval (REI) and Pre-Harvest Interval (PHI) so farmers can be trained to look at the pesticide label information to determine when it is safe to both enter the field and harvest produce after spraying. Farmers who use pesticides repeatedly throughout the year may choose to avoid these risks, and will need to be trained on, and make the personal decision to buy and use PPE to protect themselves.

Each pesticide AI has physical and chemical characteristics, such as solubility in water and inherent ability to bind to soil particles and be held there (adsorbed). And each has a breakdown rate in nature, under both aerobic and anaerobic circumstances found in the soil. The ability of pesticide chemicals to make it intact all the way to groundwater is limited by these factors—and not just by solubility in water. If the chemicals are strongly held by soil, there is more time for them to be held and broken down by hydrolysis, oxygenation, and exposure to soil microbial digestion, and they do not enter the soil water interface and the groundwater table intact as easily. A listing of these properties for most of the pesticide AIs in use in Burkina Faso and Niger can be found by checking at this website: http://sitem.herts.ac.uk/aeru/ppdb/en/atoz.htm, searched by AI.

In general, known groundwater polluting pesticide AIs are well known, due to being found intact and persisting in groundwater in sufficient quantities through frequent testing in most developed countries. Herbicide AIs atrazine and metolachlor are common examples and glyphosate may persist in the soil and water longer than previously thought possible. Known groundwater pollutants are rejected for REGIS farmer use; however, *potential* groundwater pollutants are not rejected for use, due to lack of sufficient evidence of presence in groundwater samples.

Beyond known groundwater pollutants, pesticide AIs with water solubility greater than 3 mg/liter have the *potential* to contaminate groundwater; and pesticide AIs with a soil adsorption coefficient of less than 1,900 have the potential to contaminate groundwater. In addition, pesticide AIs with an aerobic soil half-life greater than 690 days or an anaerobic soil half-life greater than 9 days have the *potential* to contaminate groundwater. Moreover, pesticide AIs with a hydrolysis half-life greater than 14 days have *potential* to contaminate groundwater.

These factors, combined, allow groups like EPA and Pesticide Action Network (PAN, a pesticide NGO) to calculate groundwater pollution *potential* proxy values, which we use in our analyses. The *potential* for pesticides to enter groundwater resources depends, as indicated above--not on solubility alone--nor on the electrical charge contained on a pesticide molecule and its ability and propensity to adhere to soil particles, but on the nature and charge of the soil particles predominant in the agriculture production area. Sand, clay and organic matter, as well as different combinations of these, have different charges and adhesion potential for organic and inorganic molecules. Sandy soil generally has less charge capacity than clay or organic matter, and will thus not interact significantly with and hold charged pesticide molecules. So, in areas with sandy soil, the leaching potential for pesticides is increased, as is the velocity with which water and the pesticide AIs can migrate.

A pesticide's ability to enter groundwater resources also depends on how quickly and by what means it is broken down and the distance/depth (and thus time) it must travel to reach the groundwater. If the groundwater table is high, the risk that the pesticide will reach it intact, before being broken down is increased. Thus, a sandy soil with a high-water table is the riskiest situation for groundwater contamination by pesticides. These acute, chronic and groundwater pollution potential risks are detailed in Annex 4 for each approved pesticide AI.

RECOMMENDATION:

- Do not promote pesticides with water pollution *potential* if farms are located on high water tables with predominantly sand soil.

5.6 FACTOR F: EFFECTIVENESS OF THE REQUESTED PESTICIDE FOR THE PROPOSED USE

This section of the PERSUAP requires information like that provided previously, but more specific to the actual conditions of application and product quality. This section considers the potential for use of low-quality products as well as the development of pest resistance to proposed pesticides, both of which will decrease effectiveness (efficacy).

Local knowledge is essential to choosing the correct pesticides. Local farmers know what has or has not worked for them in the past, and REGIS projects can increase local knowledge as to what is available, possibly effective, and presents the lowest risk.

The development of resistance of pests to pesticides used on REGIS projects crops will likely occur with increased use. Many farmers still over- and under-dose and use non-selective pesticides, all of which increase chances for resistance development. The primary tool in the battle against the development of resistance is to rotate among available chemical classes and/or modes of action, preceded by using preventive non-chemical IPM tools and tactics.

ISSUE: LACK OF KNOWLEDGE AND INFORMATION ON PESTICIDE EFFECTIVENESS

At some point, project field staff and demonstration farmers may begin to note that some products no longer work well to control pests in their field, and will likely begin to blame pesticide manufacturers for a weaker product. This could be the development of insecticide resistance, improper dosing or use of cheap generic products from unreputable companies. Farmers should be trained to monitor for the development of insecticide resistance, and project implementers should be on the lookout for it during their field visits.

WAYS TO ADDRESS AND MANAGE OR MITIGATE PESTICIDE RESISTANCE IN THE FIELD

Use IPM to minimize pesticide use: Minimizing pesticide use is fundamental to pesticide resistance management. IPM programs incorporating pest monitoring in USA show reductions in pesticide use with an increase in crop quality.

Avoid Backpack Mixes with Same Mode of Action: Never combine two pesticides with the same mode of action in a backpack mix, as this increases the chances of selection for resistant individuals. In some cases, mixing pesticides from two different classes provides superior control. However, long-term use of these two-class pesticide mixes can also give rise to pesticide resistance, if resistance mechanisms to both pesticides arise together in some individuals. Continued use of the mixture will select for these multiple-pesticide-resistant pests.

Avoid Persistent Chemicals: Insects with resistant genes will be selected over susceptible ones whenever insecticide concentrations kill only the susceptible pests. An ideal pesticide quickly disappears from the environment so that persistence of a 'selecting dose' does not occur. When persistent chemicals must be used, consider where they can be used in a rotation scheme to provide the control needed and with a minimum length of exposure.

Use Long-term Pesticide Rotations: Resistance management strategies for insects, weeds, and fungal pathogens all include rotating classes of pesticides. Pesticides with the same modes of action have been assigned group numbers by their respective pesticide resistance action committees, Insecticide Resistance Action Committee (IRAC)1, Fungicide Resistance Action Committee (FRAC)2 and Herbicide Resistance Action Committee HRAC3. These group numbers have been included in the treatment tables of these committee’s guidelines (see foot-noted websites, below) to help clarify which pesticides can be rotated.

The strategies used for rotations differ by type of pesticide: For example, with fungicides, classes should be rotated every application. With insecticides, a single chemical class should be used for a single generation of the target pest followed by a rotation to a new class of insecticide that will affect the next generation and any survivors from the first generation. Longer use of a single chemical class will enhance the chance of resistance since the survivors of the first generation and the next will most likely be tolerant to that class. Rotating through many chemical classes in successive generations will help maintain efficacy.

RECOMMENDATIONS FOR MITIGATION

- Through training, project field staff shall increase local knowledge on the classes of pesticides available, effective, and present the lowest risk (see Annex 4).
- Project field staff shall teach farmers and other beneficiaries to rotate pesticides to reduce the build-up of resistance.
- Project field staff shall monitor for resistance by noting any reduction in efficacy of heavily-used pesticide products.

5.7 FACTOR G: COMPATIBILITY OF THE PROPOSED PESTICIDE USE WITH TARGET AND NON-TARGET ECOSYSTEMS

This section examines the potential effect of the pesticides on organisms other than the target pest. Non-target species of concern include endangered species as well as fish, honeybees, birds, earthworms, aquatic organisms, and beneficial insects. The potential for negative impact on non-target species should be assessed and appropriate steps identified to mitigate adverse impacts; and this would be included in REGIS projects’ EMMPs. Annex 4 shows the relative

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1 http://www.irac-online.org/

2 http://www.frac.info/

3 http://www.hracglobal.com/

known risks to the different types of terrestrial and aquatic organisms referred to for each pesticide active ingredient approved and likely to be used, so that informed product choices can be made if the pesticide is to be used in or near sensitive areas or resources.

Maps contained in USAID Biodiversity and Tropical Forestry Assessments show natural resources in Burkina Faso (http://www.usaidgems.org/Documents/FAA&Regs/FAA118119/BurkinaFaso2007.pdf) and Niger (https://rmportal.net/framelib/Niger_118_119.pdf). REGIS users of this PERSUAP are encouraged to download, read and refer to these assessments when making project decisions near protected areas and species.

ISSUE: PROTECTED AREAS AND BIODIVERSITY

This PERSUAP study finds that there are no project sites within 10 kilometers of protected areas, which is a sufficient buffer zone[4]. If this changes over the course of USAID projects implementation, consider putting a buffer zone to protect natural resources in these important sites.

ISSUE: PESTICIDE PERSISTENCE

The effect of each pesticide on non-target ecosystems will depend on how long it stays in the environment, or rather its rate of breakdown, or half-life. Half-life is defined as the time (in days, weeks or years) required for half of the pesticide present after an application to break down into degradation products. The rate of pesticide breakdown depends on a variety of factors including temperature, soil pH, soil microbe content and whether the pesticide is exposed to light, water, and oxygen. Many pesticide breakdown products are themselves toxic, and each may also have a significant half-life. Since pesticides break down with exposure to soil microbes and natural chemicals, chemical reactions, sunlight and water, there are half-lives for exposure to each of these factors.

In the soil, types and numbers of microbes, water, oxygen, temperature, pH, and soil type (sand, clay, loam) all affect the rate of breakdown. Most pesticides also break down, or photo-degrade, with exposure to light, especially ultraviolet rays from sunshine. Lastly, pesticides can be broken down, or hydrolyzed, with exposure to water by hydrolysis. Pesticides with a long residual period (that are labeled persistent and last for years) include atrazine herbicide and organochlorine pesticides. Many of the newer pesticides break down much quicker, generally within weeks, in the environment.

RECOMMENDATIONS FOR MITIGATION

During training, project field staff shall teach farmers to:

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[4] http://www.cerium.ca/IMG/pdf/Primitive_ideas.pdf

- consider the toxicity, half-life and breakdown products of pesticides during the selection process, and choose pesticides that are less toxic and break down quickly in the environment.
- avoid using pesticides in or within a 10-km buffer zone from protected areas or national parks and where endangered species are known to exist.
- investigate the use of botanical and biological controls, as practical, or produce Organic crops near these valuable natural resources, if agricultural production is done within 10km up-wind or up-stream from a protected area.
- minimize chemical spray drift by using low-pressure sprays and nozzles that produce large droplets, properly calibrating and maintaining spray equipment, and use of a drift-control agent.
- warn beekeepers of upcoming spray events so that they may move or cover their hives.
- apply pesticides late in the afternoon after honeybees have finished foraging.
- not apply pesticides during heavy rains or winds, and follow instructions on pesticide packaging.
- apply pesticides at least 35 meters from open water.

5.8 FACTOR H: CONDITIONS UNDER WHICH THE PESTICIDE IS TO BE USED, INCLUDING CLIMATE, GEOGRAPHY, HYDROLOGY, AND SOILS

In general, in addition to Factor G above, this requirement attempts to protect natural resources from the dangers of pesticide misuse and contamination, especially of soil and groundwater resources. These conditions, climate, geography, hydrology and soils are covered well in the above-referenced Biodiversity and Tropical Forestry Assessments. Please see these assessments to understand these conditions for each country.

RECOMMENDATIONS TO REDUCE RISKS

- **Hydrology:** Train farmers to not spray or rinse pesticide equipment in or within 30 meters of oasis resources, rivers, ponds, irrigation and drainage ditches, and other surface waters, including wetlands.
- **Climate and Hydrology:** Train farmers to not spray pesticides with high toxicities to aquatic organisms before an impending rainstorm, as they can be washed into waterways before breaking down.
- **Soils:** Train farmers to not use or recommend for use pesticides with high leaching and groundwater pollution potential (see above, under Factor E) near drinking water sources, on highly sandy soils or soils with water tables close (2-3 meters) to the surface.
- **Soils:** Since transport of soil particles with pesticides adsorbed to them is a likely transportation route to waterways, REGIS employs techniques to reduce farm soil erosion whenever erosion is likely. Such techniques, that can and are being taught to beneficiary farmers, include vegetated buffer strips, green manure, mulching, terracing, employing wind breaks, employing ground covers between rows, planting rows perpendicular to the slope, and using drip irrigation.

5.9 FACTOR I: AVAILABILITY OF OTHER PESTICIDES OR NON-CHEMICAL CONTROL METHODS

REGIS plans to promote, as much as possible, IPM and GAPs in Burkina Faso and Niger. As noted, the "pests and preventive tools" tables presented in Annex 1 for each target crop, livestock, poultry and activity serve as rough drafts for the crop- and pest-specific pest management plans to be developed by REGIS after this PERSUAP has been reviewed and approved.

In Annex 1, many non-pesticide preventive tools are recommended as control measures, some of which are already being practiced by smallholder farmers. For many crop pests and diseases, only non-chemical controls are recommended. However, as established, effective pest management across the target crops, and activities, particularly at larger and more intensive production scales, is likely to require some chemical controls. As noted, pesticide use/support will be governed by activity-, crop- and pest-specific pest management plans. A major purpose of these plans is to assure a well-considered mix of non-chemical preventive and chemical controls.

Pest management will focus on improved crop management practices and crop varieties, and proper materials management and control, as well as biological, cultural, physical, mechanical, and other preventive IPM control methods discussed above, under Factor C. REGIS-ER has training planned in IPM for garden crops, for phytosanitary brigade members, Community Based Solution Provider (CBSP), and Moringa oasis garden managers.

RECOMMENDATIONS

- Annex 1 can be used as a pullout, stand-alone section that can be reproduced as necessary, and should be considered for adaptation, translation into the local language—French, lamination, and distribution to project field staff to help advise beneficiary farmers.
- Preventive IPM tools and tactics for each commodity-pest combination in Annex 1 should be tried and locally adapted before the choice is made to purchase and use synthetic pesticides.
- Annexes 2 and 3 provide guidelines for making PMPs and using IPM. For most pests, diseases and weeds, Annex 1 provides many choices of preventive tools and tactics to integrate with very few choices of natural and synthetic pesticides to choose from.

5.10 FACTOR J: HOST COUNTRY'S ABILITY TO REGULATE OR CONTROL THE DISTRIBUTION, STORAGE, USE, AND DISPOSAL OF THE REQUESTED PESTICIDE

Burkina Faso and Niger, as part of CILLS (*Comité permanent inter-État de lutte contre la sécheresse au Sahel*), helped produce a common regulation and pesticide registration through INSAH, and the MOA in each member country is responsible for implementation and enforcement of regulations. Risks arise from the quantities of cheap fake, adultured/diluted and counterfeit pesticides being imported illegally from Nigeria and Ghana. Smallholder farmers often cannot afford the newer, much costlier patent-protected pesticides, so they buy cheaper generics.

Also, smallholder farmers who purchase re-packaged pesticides stored in empty water or juice bottles, or re-used EPCs take the risk of not knowing exactly what chemicals are in the bottle and on their produce, or how to respond if their child is poisoned. Many of the smallholder farmers who use pesticides do not use mandated PPE.

Information collected about the Burkina Faso and Niger pesticide system (from interviews with governments, pesticide wholesalers and retailers, as well as farmers) indicates that most farmers do not understand the importance of safely disposing of EPCs. Many Burkina Faso and Niger farmers simply throw the empty containers in the field, or reuse them.

The best method for container disposal in Burkina Faso and Niger is to triple-rinse the containers, puncture them to discourage re-use, and bury them, dispose of them in municipal waste, or recycle them if such a facility exists. REGIS should strongly discourage burning plastic bottles and single-use pesticide sachets, which can lead to the formation of toxic fumes containing carcinogenic furans and dioxins.

Governments budgets remain highly challenged to do comprehensive control of pesticides entering the country, auditory pesticide quality tests, and enforcement of regulations on safe distribution, storage, use and disposal.

RECOMMENDATIONS

- If they appear in Burkina Faso and Niger, absolutely no POP or PIC Treaties chemicals will be used or supported on the REGIS program.
- Where alternatives (WHO Classes III and U) exist, do not recommend or use WHO acute toxicity Class II (as noted on the labels, and which are generally equivalent to EPA Class II acute toxicity) pesticide products, except for use by highly trained, certified and protected staff of pest control companies.
- Train farmers to purchase inputs from suppliers that provide quality technical backup support, and to purchase and use PPE, or contract private pesticide spray services.
- Train farmers to properly dispose of containers and strongly discourage burning them.
- Train farmers about proper storage and handling of unused pesticides.

5.11 FACTOR K: PROVISION FOR TRAINING OF USERS AND APPLICATORS

USAID recognizes that, in addition to the promotion of IPM and use of PPE by the few smallholder farmers using pesticides, safety training is an essential component in programs involving the use of pesticides, be they artisanal or synthetic. The need for thorough training is particularly critical in Burkina Faso and Niger, where the level of education of applicators may typically be low.

As the REGIS program discusses or promotes pesticide use, training in GAP/IPM tools and tactics and SPU and are mandatory for project beneficiary farmers using pesticides (see Annex 6 for recommended training topics). Repeat refresher training courses are necessary for changing beneficiary farmer behaviors, especially as they expand their agricultural opportunities.

As noted from the start of this report, in addition to professional pesticide application services, REGIS projects work with provision of seed, seedlings and technical advice for household and market garden vegetables, food security protein and carbohydrate crops, as well as fruit trees, livestock, and poultry.

Recommended pesticide choices, where appropriate, are provided in Annex 1, by crop, livestock, poultry, and use sector (for instance grain storage), as well as by primary pests, diseases and weeds. Farmers are always trained to read pesticide labels or pictograms to determine risks, risk reduction, PPE, recommended uses and dosage.

TOP BURKINA FASO AND NIGER TRAINERS AND TRAINING

REGIS projects have access to the top Burkina Faso and Niger agronomists with graduate degrees, in addition to the top two environmental compliance specialists who have graduate degrees as well as local expertise in agriculture. These local experts produced the extensive list of crops, fruit, livestock, and other information used for compiling Annex 1 as well as the extensive lists of local pests and diseases of each culture.

REGIS projects practice continuous learning and use continuous, day to day, hands-on training with farmer village cooperatives and all their members. Many smallholder farmers cannot afford, and do not use, commercial pesticides, relying instead upon thousands of years of local knowledge, collective experience and remedies for managing pests. This includes use of local artisanal concoctions from local plant and spice extracts and other materials to repel or reduce pests.

TRAINEES

All cooperating smallholder farmer beneficiaries of REGIS assistance will continue to be trained in GAPs, as well as pest identification, IPM and SPU in general.

CHOICE TO USE OR NOT USE PPE

The decisions to use or not use PPE are made by individual farmers, based upon an understanding of risk as learned in training and read on pesticide labels, the amount of pesticides used, frequency of use, relative toxicities, local availability of PPE, cost of PPE, individually-acceptable levels of risk and risk reduction, and other factors irrespective of technical training and information received. Many times, suitable PPE is not available or affordable. Thus, one cannot consider farmers who choose not to use PPE as “untrained”. As with many non-commercial smallholder farmers in developed countries making these same decisions, many choose to assume the risks themselves by not buying and using PPE. The only way to fully enforce use of PPE is to subsidize it and make its use a condition for receiving assistance, as with S&C systems, which is unlikely to happen with USAID.

CONTINUOUS TRAINING

REGIS training must require any pesticide users to interpret product labels to understand product health risks, physical hazards, eco-toxicity and required safety measures. Continuous training requirements are specified in the attached SUAP.

A core strategy of many FFP projects is to promote knowledge about preventive IPM tools and tactics as well as pesticide use, risks, and safety among beneficiaries, and to strengthen the agricultural extension abilities and encourage farmers and other applicators to use them for advice. While most of the pesticide AIs put forward for approval by this PERSUAP are generally of toxicities at or lower than Class II, the pesticide toxicology profiles presented above under Factors E and F clearly show that use of any pesticides present some human health and environmental risks. SPU training is essential for the following groups:

- Project staff who serve as extension agents;
- Beneficiary farmers and other users who will use/apply pesticides;
- Any cooperating governments extension agents.

REGIS will be responsible for providing appropriate PPE training and equipment for demonstration plot farmers and pesticide use trainees. REGIS may, as appropriate, also encourage and work with retail agro-input supply stores on best practices and to increase PPE supplies and affordable use options for smallholder farmers. Field officers will continue to provide training and technical assistance to farmers on integrated pest management of fruit and vegetable plots (see Annex 1). The following is a summary of pesticide safer use training topics to be addressed, as copied from USAID environmental compliance websites and pesticide labels:

<u>Chemical knowledge</u>: Registration, correct use, application procedures and label specifications. This training includes an in-depth review of label information (resources in French and/or with photos will continue to be provided wherever possible), as well as a discussion of human risks, risks to environmental resources, dosage rates, application rates, equipment calibration and maintenance, application intervals, re-entry and pre-harvest intervals and demonstrations of proper equipment use. Record keeping and monitoring of the pesticide application and storage will also be presented.

<u>Storage</u>: Proper storage of chemicals in relation to other structures on the property. The need for a separate, clearly marked and locked facility will be emphasized for exclusive storage of farm chemicals. Pesticides should be kept away from food for human or animal consumption, fertilizers, or sources of drinking water. Pesticides should always be bought and stored in their original containers.

<u>Transport</u>: Safe transport of pesticides will be discussed. Such best practices include, if possible, not using public transportation where others may be exposed, not transporting pesticides with foodstuffs, keeping chemicals in a protected environment, and how to avoid punctures and torn bags.

Worker protection: Types of PPE as recommended on the pesticide labels, when they should be worn and why, and how they should be cared for. The basic PPE recommended for all pesticide applications includes frequently laundered or cleaned long-sleeved shirts, long pants, shoes and socks. Depending on the toxicity and label directions, chemical-resistant gloves, aprons, and filter masks may be required, which would be provided by REGIS or are available at local agro supply stores. Participants will be encouraged to wash PPE separate from everyday clothing and to keep their PPE in good condition.

Safety practices: Proper mixing techniques, the importance of using clean water for mixing, and the importance of not contaminating water sources with rinsate or mix. The types of containers used in chemical preparation, their proper use, cleaning and storage will be addressed. Applicators are taught not to eat, drink or smoke while applying pesticides.

First aid and medical facilities: First aid materials must be made available (antidote, if one exists, soap, clean water and a towel) in case of spills. Participants will be taught to identify the primary symptoms of chemical exposure and what do to in an emergency.

Waste management: How to clean up and safely dispose of any unused, leftover or obsolete chemical. For liquids, empty containers should be rinsed three times, and rinsate emptied into the spray tank as part of the application mixture. When the product is used completely, chemical containers should be triple rinsed and punctured before being buried or recycled. Containers should never be reused.

Protection of drinking water: Training will emphasize the importance of protecting potable water sources and avoiding contamination of ground and surface waters. Participants will be trained to identify their drinking water source and to keep all pesticides away from that source. Characteristics of the water source and mitigation measures to avoid contamination will be addressed.

Environmental safety: The importance of protecting natural resources and the proper use of pesticides to avoid environmental contamination and impacts on non-target organisms will be addressed. For groups promoting pesticide use, an additional training phase may be targeted to women, children or sick individuals who may enter production fields or who may be exposed indirectly to spray drift or residues on the pesticide user's clothing at home.

RECOMMENDATION

REGIS should develop training plans meeting its specific needs:

- The training plan must cover the categories of individuals enumerated above.
- Training curricula must cover all relevant key topics outlined above and in more detail in Annex 6.

- Training must reach all relevant individuals within an appropriate time interval of the effective date of this PERSUAP.
- Brief refresher training must be provided to appropriate personnel at least annually.
- REGIS is encouraged to consider the training-of-trainers approach.

5.12 FACTOR L: AVAILABILITY OF OTHER PESTICIDES OR NON-CHEMICAL CONTROL METHODS

This section identifies less toxic synthetic, as well as non-synthetic or 'natural' pesticide options for control of pests, and their relative advantages and disadvantages. Many of these 'natural' pesticides can be toxic to humans, and some natural pyrethrum pesticides (not proposed or evaluated in this PERSUAP) are classified as RUP due to aquatic ecotoxicty risks; thus, safe pesticide use practices extend to these natural as well as synthetic (produced in laboratories or factories) pesticides.

Annex 1—the heart of this PERSUAP—contains numerous preventive non-chemical control tools and tactics for every major pest of every REGIS-supported crop in Burkina Faso and Niger. It is the intent of this PERSUAP that REGIS projects dealing with agriculture use this valuable resource, which compiles known IPM tools and tactics for each pest, as recommended for the same crop-pest/disease pairings in other countries.

ISSUE: NATURAL PEST CONTROLS AVAILABILITY

As noted above, under Section 3, several local artisanal pesticides are made and used by smallholder farmers and NGOs.

RECOMMENDATION

- REGIS promote the use of natural artisanal pest and disease control products and NGOs that produce them
- *Caution: Not all natural products are safe to use. USAID-sponsored projects should support and promote only the use of artisanal pesticides with an acceptable level of characterization and generally recognized as safe: e.g. garlic and chilli pepper extracts, neem, etc. Many plant extracts are effective insecticides because they contain alkaloids, which can be toxic also to man and a range of non-target organisms. Likewise, also some non-pesticidal preparations, such as the well known "bokashi" fertilizer, give reasons for concern because of the possibility to contaminate crops with fecal coliform bacteria.*

5.13 FACTOR M: HOST COUNTRY'S ABILITY TO REGULATE OR CONTROL THE DISTRIBUTION, STORAGE, USE, AND DISPOSAL OF THE REQUESTED PESTICIDE

This section examines the host country's existing infrastructure and human resources for managing the use of the proposed pesticides. If the host country's ability to regulate pesticides is inadequate, the proposed action – use of pesticides – could result in greater risk to human health and the environment.

The MOAs in both Burkina Faso and Niger have limited resources available for research, extension, certified laboratories and enforcement services.

ISSUE: LIMITED RESOURCES TO CONTROL PESTICIDES

Burkina Faso and Niger have limited systems and resources for enforcing the registration and regulation of the import, sale, and use of pesticides. Further, their ability to cover the country and eliminate banned, counterfeit or highly toxic chemicals is limited due to limited resources. The list of pesticides available contain some toxic chemicals that should not be handled by illiterate, untrained, unprotected and often unaware small-holder farmers. Most farmers do not have access to and cannot afford PPE to follow GAPs.

ISSUE: DISPOSAL OF PESTICIDE CONTAINERS

Some farmers in Burkina Faso and Niger retain empty and partially full plastic pesticide containers. Some use these to store water, milk, honey or cooking oil. Before disposal, the standard practice has been to triple-rinse the containers, puncture them to discourage re-use, and bury or burn them. Burning plastic bottles and single-use pesticide sachets can lead to the formation of toxic (and POPs) furans and dioxins, and is not recommended. GlobalGAP and other S&C systems require that empty pesticide containers are triple rinsed over a pesticide soak pit with layered soil, lime and carbon, or a bioactive pit with compost, and then properly stored in plastic drums in the field or storage shed, to await disposal or recycling. There is no pesticide container recycling activity in the Sahel. A WHO website footnoted below[5] provides pesticide container disposal options.

RECOMMENDATIONS FOR MITIGATION

Project field staff shall:

- as feasible, through contacts with the government of Burkina Faso and Niger, encourage and follow developments in the regulation and registration of pesticides.
- ensure that absolutely no POPs or PIC chemicals shall be used on REGIS projects.
- shall, during training, encourage and support the use of GlobalGAP best practices with pesticide storage, use and disposal, whether certification is required for market access.

5.14 FACTOR N: PROVISION FOR TRAINING OF USERS AND APPLICATORS

USAID recognizes that, in addition to the use of PPE, safety training is an essential component in programs involving the use of pesticides. The need for thorough training is particularly acute

[5] http://www.who.int/whopes/recommendations/Management_options_empty_pesticide_containers.pdf

in developing countries, where the level of education of applicators may typically be lower than in developed countries.

ISSUE: FARMERS NEED INTENSIVE AND REPEATED TRAINING

Training in SPU and GAP/IPM are of dominant importance for REGIS projects farmers and farm laborers using pesticides. REGIS projects should focus strongly on providing GlobalGAP, IPM and SPU training. Additional and refresher training are superb means for changing beneficiary farmer behavior, now, as they continue to expand their agricultural opportunities, and before risky behaviors become further set.

RECOMMENDATIONS FOR MITIGATION

Project field staff shall:

- implement GAP, IPM and Pesticide Safe Use training for REGIS projects staff and beneficiaries.
- use Annex 1 to produce and promote the use of Pest Management Plans for farmers to anticipate and better manage primary pests.

5.16 FACTOR M: PROVISION MADE FOR MONITORING THE USE AND EFFECTIVENESS OF EACH PESTICIDE

Evaluating the risks, impacts and benefits of pesticide use should be an ongoing, dynamic process. Proper pesticide use and pest resistance are two of the risks that this factor is intended to address, as well as human health and safety and environmental effects.

On the farm, record keeping should track quantities and types of pesticides used, where they were used and what they were used for, with notes on efficacy. Notes on effectiveness of individual pesticides and pest numbers will help develop a more sustainable pesticide use plan for REGIS program beneficiary farmers. Farmers will need to keep records of any reduction in pesticide efficacy experienced, which is the first indication that pest resistance may be developing. Then a strategy needs to be in place to determine a shift to a different pesticide class, and rotation among classes, to overcome resistance development.

The following aspects should be included in all REGIS program record keeping systems:

- The following website provides a format and ideas for farmers for record keeping on crops and livestock grown, pests/diseases encountered and pesticides sprayed, among other pieces of data: http://agriculture.vic.gov.au/agriculture/farm-management/chemical-use/agricultural-chemical-use/record-keeping-agricultural-chemicals.
- A pesticide checklist: This list allows project agronomists to ensure that the pesticides they are using are registered. It should also provide notes on special safety requirements.
- PPE: Lists of the types of equipment made available to applicators, number of pieces, prices and contact details of suppliers, dates when equipment needs to be washed,

maintained or replaced. PPE should be numbered or personally assigned to applicators to ensure that it is not taken into the home where (as a contaminated material) it could pose a risk to family members.

- Local regulatory compliance: A list of country laws related to the use of agrochemicals for plant protection.
- GAPs/IPM measures tried/used (see Annex 1) for each crop-pest combination.
- Annex 1 can be used as a pullout, stand-alone section that can be reproduced as necessary, and should be considered for local adaptation, translation into the local language— Kirundi, lamination, and distribution to project field staff to help advise beneficiary farmers.
- Monitoring/recording pests: Agronomists should incorporate into their records regular field pest monitoring and identification. This could be done by the REGIS program agronomists themselves, or if properly trained, by farmers.
- Environmental conditions: Field conditions should be incorporated into the record keeping system (for example; precipitation, soil analyses and moisture, soil pH, temperatures and so on).
- Information should be transmitted at least annually and the FFP program should report to USAID on this progress in pesticide safety and GAP/IPM use in annual reports.

SECTION 6: PESTICIDE SAFE USE ACTION PLAN (SUAP)

6.1 INTRODUCTION TO SUAP

This Safe Use Action Plan, is the definitive statement of REGIS program pesticide compliance requirements and is synthesized from the PER analysis:

Section 6.2, immediately below, cites the locations in this Agriculture PERSUAP where users can find the approved pesticides.

Section 6.3 establishes USAID field monitoring requirements for compliance with safe use conditions.

Section 6.4 summarizes the recommended best practices and safe use conditions to be used/supported with these pesticides.

The REGIS program will be required to insert into an Environmental Mitigation and Monitoring Plan (EMMP) foreseeable risks and the appropriate recommendations from the PER that are applicable to their project that will reduce each of these risks. The EMMP should also include indicators of risk mitigation success, a monitoring timetable and responsible people/groups for implementation of these requirements, and for tracking compliance. REGIS's EMMP should include details on who will be trained, in which topics, and how often. The REGIS EMMP should have measurable and monitorable indicators to be reported on in progress reports to USAID.

6.2 REGIS PESTICIDES REQUESTED FOR ANALYSIS

Upon approval of this PERSUAP, the pesticide AIs and products listed as "approved" in the Executive Summary—and ONLY those AIs/products—may be supported by the REGIS program and their sub-grantees covered by this PERSUAP. Such support is subject to the safe use conditions summarized below and set out in detail in this SUAP.

Allowed pesticides are those that passed the 12-factor analyses, particularly Factor A (EPA & INSAH Registration and RUP Status), Factor C (Use of IPM in Annex 1), Factor E (Acute/Chronic Toxicological Hazards), and Factor F (Efficacy/Resistance) as analyzed and summarized under those factors. Synthesizing across the PER analysis, ONLY the pesticide AIs in the Executive Summary—and with the implementation of specific noted conditions for any of the chemicals—are approved for use or support or promotion on REGIS program and any sub-grantees.

6.3 USAID REQUIREMENT

In addition to continuous monitoring by the REGIS and their sub-grantees, environmental compliance staff and others delegated, USAID's AOR and MEO should at least two times annually, make inspection visits to several randomly selected demonstration farms receiving project assistance to check for compliance with the IPM and SPU measures summarized in section 6.4 below.

6.4 COMPLIANCE REQUIREMENTS (SAFE USE MEASURES)

The approved pesticide AIs can only be used in compliance with the safe use measures and recommendations specified in the PER. The most important of these can be summarized as follows:

A. Only pesticides approved by this Agriculture PERSUAP may be "supported" with REGIS funds. Pesticide "support" refers to any or all the following, as applicable:

a. Use of USAID funds to purchase pesticides, sprayers, sprayer parts, PPE;

b. Directly fund the application of pesticides by farmers or spray services;

c. Promote or recommend pesticides for use during training or on demo farms; and/or

d. Facilitate or enable the application or purchase of pesticides via provision of credit support, vouchers, or other means by the REGIS, their sub-grantees, partners or providers of finance.

If pesticide use is supported, appropriate project staff, sub-grantees and beneficiaries must be trained in recommended preventive IPM tools and tactics (Annex 1), SPU and pesticide first aid. Annex 1 can be used as a pullout, stand-alone section that can be adapted, reproduced as necessary, and should be considered for adaptation, translation into a local language, French, lamination, and distribution to project field staff to help advise beneficiary farmers.

To the greatest degree practicable, if pesticide use is supported by the REGIS program or their sub-grantees, they must require use and assure maintenance of appropriate PPE—as well as safe pesticide purchase, handling, storage and disposal practices.

REGIS shall provide details in their project-specific EMMP of how they will implement the relevant recommendations from the PER, and if this SUAP is revised, as recommended, the EMMP will have to be revised as well.

Additional PERSUAP best practices and risk reduction recommendations are found under each of the Factor A-L analyses, under Section 5, the PER analysis.

Projects Titles: **Resilience and Economic Growth in the Sahel - Enhanced Resilience, Acclerated Growth**					
Pesticide(s): Various (see PERSUAP pp 10-15)			Crops: Various (see PERSUAP p 9)		
Location Common Name(s): Various (see PERSUAP Annex 1)			Target Pests: Various (see PERSUAP Annex 1)		
Required Compliance Mitigation Measures		Compliance Dates	Actions to achieve compliance	Responsible Party	Status
Capacity Building	Technical Assistance for Trainers	08/15/18	train by int. crop protection expert	REGIS environ. officers	Will begin with PERSUAP approval
Capacity Building	Development and Distribution of Educational Material	11/15/18	development/dist. by int. crop protection expert	REGIS environ. officers	Will begin with PERSUAP approval
Capacity Building	Training of Pesticide Handlers	12/30/18	train by int. crop protection expert	REGIS environ. officers	Will begin with PERSUAP approval
Local Issues	Establish Pesticide Quality Standards	09/15/18	MOA work w/ int. crop protection expert	REGIS environ. officers	Will begin with PERSUAP approval
Local Issues	Require Good Packaging and Clear, Adequate Labeling	09/15/18	MOA work w/ int. crop protection expert	REGIS environ. officers	Will begin with PERSUAP approval
Safer Pesticide Use	Ensure Accessibility of Personal Protective Equipment	08/15/18	ensure by int. crop protection expert	REGIS environ. officers	Will begin with PERSUAP approval
Safer Pesticide Use	Define Appropriate Procedures for Safe Pesticide Transport	08/15/18	define by int. crop protection expert	REGIS environ. officers	Will begin with PERSUAP approval
Safer Pesticide Use	Define Appropriate Methods for Safe Pesticide Storage	08/15/18	define by int. crop protection expert	REGIS environ. officers	Will begin with PERSUAP approval

	Define Disposal Provisions for Used Pesticide Containers	08/15/18	define by int. crop protection expert	REGIS environ. officers	Will begin with PERSUAP approval
Long-Term Program	Coordination, Collaboration, Awareness raising, Surveillance, Control Management, Research	06/15/18	To be on-going, w/ assistance of int. crop protection expert	REGIS environ. officers	Will begin with PERSUAP approval

ANNEX 1: IPM MATRIX FOR REGIS CROPS, LIVESTOCK, PRIMARY PESTS, DISEASES, AND WEEDS

The following matrices are organized by crop, primary pests, diseases and weeds, with common names if known in French, descriptions of each and the damage they cause, preventive measures found being used by farmers in Burkina Faso, as well as from IPM websites for the same pests in the USA and Africa, followed by pesticide AIs and product Trade Names. This matrix is provided as a baseline for REGIS technical staff and MOA extensionists to adapt and adopt, using local information, resistant hybrids and other tools already in use by farmers.

Cassava/Manioc

Cassava, *Manihot esculenta*, is a woody shrub, native to South America, which was introduced into Africa by Europeans, where it was not adapted to local pests and diseases. The roots form tubers, which are edible and are the third most important source of carbohydrates after rice and maize. Some ‘bitter’ cassava varieties have tubers that produce toxic cyanide, which needs to be removed before consumption. In West Africa, cassava is also fermented into a local product called fufu, which contains useful human gut probiotics. Cassava leaves are harvested and cooked as a nutritional local 'spinach' in Niger and Burkina Faso.

Table 2. Cassava/Manioc			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Cassava Mosaic Virus, CMV, transmitted by whitefly (*Bemisia tabaci*)	Leaves deform, curl and turn mottled yellow. Crop production is reduced. See whitefly descriptions below. A major constraint that limits production in the Sahel.	Use new resistant varieties. Plant only certified virus-free propagation materials. Sanitation: Remove diseased plants from the field, and destroy.	No treatment threshold To kill whitefly vector: neem seed extract garlic extract chili extract acétamipride

Table 2. Cassava/Manioc			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			(Titan 25 EC) spinosad (Laser 480 EC)
Soil pest: Termites (*Coptotermes spp.*)	Termites are generally white to cream-colored, 3-7 mm, with red-brown heads. They live in a protected nest or mound and travel to crops through dried mud and saliva tubes in the soil and up trees, stalks and other objects. The tubes protect termites from dessication. Termites feed on tree bark, often girdling twigs, branches and smaller trees, disrupting movement of nutrients and water, killing parts or the entire plant or tree. A major constraint that limits production in the Sahel.	Use tolerant varieties. Locate and destroy termite nests and mounds near crop fields. Use healthy uninfested cuttings and seedlings. Use an organic and non-organic fertilizer combination to favor the growth of the seedlings.	No treatment threshold No insecticides are recommended
Green manioc mite (*Mononychellus tanajoa*) (acariene verte du manioc)	Mites are tiny 8-legged acarids that feed with piercing mouthparts, in groups on leaf undersides. Extensive feeding causes leaf wilt and death, and is exacerbated by warm dry weather and drought. Extensive feeding leads to death and shedding of terminal shoots,	Use varieties with good tolerance to green mites such as MM96/5280, MM96/7204 and MM96/0287 Use clean plant material for planting.	No treatment threshold neem seed extract and neem seed oil (preferred)

Table 2. Cassava/Manioc			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	reducing production.	Plant at the onset of the rains to encourage vigorous growth and thereby increase tolerance to mite attack. Several cultural methods, such as adjusting planting time for the crop to escape severe damage at young age, mixing varieties to avoid genetic uniformity, and removing infested tips. Intercrop cassava with pigeon pea in double and triple rows.	garlic extract chili extract abamectine (Abalone 18 EC, Acarius 18 EC, Bomec 18 EC, Vertimec 18 EC)
MANIOC SCALE (*AONIDOMYTILUS ALBUS*)	Scales are small, 3-5 mm round, immobile insects, covered with a white-gray waxy shell-like (scale-like) covering. Female scales have neither wings nor legs. Females lay eggs under their scale. Larvae are called crawlers, which emerge from the protective scale, and move in search of a feeding site. They suck sap on all above the ground plant parts.	Use certified clean planting material, well-spaced. Do not over-crowd plants. Plant early in the rainy season. Clear heavily-infested plots and allow 3 days before replanting.	No treatment threshold neem seed extract chili extract garlic extract malathion (Fyfanon 880 EC) acétamipride

Table 2. Cassava/Manioc			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	Cassava scale coats the stems, shoots and leaf petioles undersides. Infestation in the field occurs in patches around a cutting that was infested at planting. Heavy infestation causes desiccation and thinning of stems, leading to breakage. Broken stems lead to profuse branching, making infested plants appear bushy. Root development and quality in infested plants is poor.	Use crop rotation. Use of mulch and manure decrease moisture stress and increase cassava resistance.	(Titan 25 EC) A 5-minute dip of planting material in 200 ppm malathion may be sufficient to kill any infestation (Lozano JC, Toro JC, Castro A, Bellotti AC, 1977. Production of cassava planting material. Series GE, CIAT, No.17:28pp.)
Citrus white fly (*Aleurodicus dispersus*) (Mouche blanche agrumes)	Whiteflies are tiny, 2 mm, white, insects with piercing-sucking mouthparts. They occur in groups on the undersides of leaves, laying eggs, which develop into nymphs that also suck plant sap from the leaves. Outbreaks, leading to leaf-wilting and death under drought stress, often occurs when the natural biological control is disrupted by over-use of pesticides.	Use resistant varieties. Do intercropping and interplanting crops Use yellow sticky traps for monitoring. After the last harvest, destroy all crop residues. Ensure good growing conditions for the crop. Avoid application of high doses of nitrogen fertilizer.	No treatment threshold neem seed extract garlic extract chili extract acétamipride (Titan 25 EC) spinosad (Laser 480 EC)

Table 2. Cassava/Manioc			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Cassava bacterial blight and storage rot (*Xanthomonas axonopodis pv. manihotis*)	Leaves have angular, green-blue, water-soaked spots, 1-4 mm, which eventually grown and merge along the veins or the edges of the leaf into a brown lesion with a yellow halo. A strong attack can lead to premature drying and shedding of the leaves.	Use only clean planting material. Collect cuttings only from healthy plants and from the most lignified portion of the stem, up to 1 m from the base. Visually check the cuttings for vascular browning. Disinfect cutting and planting tools regularly. Intercrop cassava with maize or melon. Practice crop rotation and fallowing. Rotation or fallowing should last at least one rainy season. Remove and burn or bury all infected plant debris and weeds.	No treatment threshold No bactericides are recommended
Cassava brown leaf spot/Cercosporiosis (*Mycosphaerella =Cercospora*	Leaves develop circular greenish-yellow spots that spread, turn angular and brown. Lesions may grow and coalesce, leading to leaf death and early	Rake and burn fallen cassava leaves during the dry season Prune away heavily	No treatment threshold

Table 2. Cassava/Manioc			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
henningsii)	drop. High humidity and warm temperatures favor disease emergence and spread of the disease is promoted by prolonged leaf wetness. Spores are spread by wind, splashing rain, and insects. Abundant leaf residue in fields where cassava is continuously grown often results in early and rapid development of leaf spots.	infected and dead debris and burn. Ensure a three to five-year period of crop rotation.	mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP) tébuconazole + trifloxystrobin (Nativo 300 SC)

Cowpea/Niébé/Black-Eyed Pea (REGIS-AG, in field and storage, also cash crop)

Cowpea, or black-eyed pea, *Vigna unguiculata*, originated in the savannah region of West and Central Africa, where it highly adapted to the local semi-arid climate, pests and diseases, and is the most important high-protein indigenous African grain legume, and a major commodity in regional trade within West and Central Africa. The relatively high protein content of cowpea makes it an essential supplement to the diet of many Africans who consume high carbohydrate but low in protein cereals, root and tuber crops. Cowpeas are cultivated for the seeds (shelled green or dried), the pods or leaves that are consumed as green vegetables or for pasture, hay, silage and green manure.

Table 3. Cowpea/Niébé/Black-Eyed Pea			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Cowpea aphid (*Aphis craccivora*) (Puceron du niébé)	This small gray/black aphid is a pest of cowpea seedlings, flowers and pods, and transmits cowpea mosaic virus (see below). Infested plants develop yellow foliage, may become dwarfed and malformed, and lose vigor. Heavy feeding kills seedlings while causing stunting, leaf distortion, delay of flowering, and reduced fruit set. Found on lower leaf surfaces and terminal buds, adults and nymphs extract plant sap with piercing-sucking mouthparts, and defecate honeydew onto leaves. Black sooty mold grows on this honeydew, reducing photosynthesis. Females produce 80 nymphs over an 18-day period. It colonizes cowpea 3 weeks after crop emergence.	Plant resistant varieties. Use crop rotation. Observe build up aphid populations and natural enemies (predators like lady bird beetles, hover flies, lacewings, parasitic wasps like *Aphidius spp*) Plant trap crops such as lupine, nasturtiums, timothy grass, anise, chives, garlic, onions, and radish near the crop to be protected. Use yellow sticky traps placed on field edges for monitoring populations.	Three weeks after crop emergence, sample 20 randomly selected plants each week. Apply insecticide if more than 20% of the plants are infested and at least 1 in 10 plants is heavily infested. Use seed treated with imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract garlic extract chili extract

Table 3. Cowpea/Niébé/Black-Eyed Pea			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	A major constraint that limits production in the Sahel.		
Cowpea pod borer (*Maruca testulalis = M. vitrata*) (Foreur de la gousse)	Maruca adults are 10-cm brown moths. Eggs are laid on flower buds. Larvae are yellow-white, with a dark head, up to 1.8 cm, with quartets of dark spots on top of each abdominal segment. Larvae secrete silk webbing around feeding sites. One larva may consume 4-5 flowers before pupation. Third to fifth instars tunnel into green pods to feed on the seeds. There is no dry season diapause; Maruca survives the dry season in the more humid southern savannah, moving northward from Nigeria with cowpea plantings in the rainy season. Larval feeding can cause losses of 20-80%.	Use trap crops like brown hemp, *Crotalaria juncea,* and destroy once infested. Parasitoids and predators provide a level of control. Use resistant varieties. Practice intercropping and crop rotation: Plant non-leguminous crops every other cropping season.	Beginning at flowering, randomly sample 20 plants each week and treat if there are 3 or more larvae total. Use seed treated with imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract chili pepper extract diméthoate (Methoate 40 EC)

Table 3. Cowpea/Niébé/Black-Eyed Pea			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	A major constraint that limits production in the Sahel.		
Soil pest: Termites (*Coptotermes spp.*)	Termites are generally white to cream-colored, 3-7 mm, with red-brown heads. They live in a protected nest or mound and travel to crops through dried mud and saliva tubes in the soil and up trees, stalks and other vertical objects structures. The tubes protect termites from dessication. Termites feed on tree bark, often girdling twigs, branches and smaller trees, disrupting movement of nutrients and water, killing parts or the entire tree.	Use tolerant varieties. Locate and destroy termite nests and mounds near crop fields. Use healthy uninfested cuttings and seedlings. Use an organic and non-organic fertilizer combination to favor the growth of the seedlings.	No treatment threshold No insecticides are recommended
Soil pest: White grub (*Phyllophaga spp*., *Heteronychus spp.*) (vers blancs)	White grubs, 2.5 cm long, with a red-brown head and dark gray end of abdomen, curling into a C-shape, are the immature forms of brown scarab beetles that fly at night after first heavy rains. The larvae feed on	Use weed management by cultivation in and around field. Avoid planting in fields that are coming out of pasture.	In 5 areas of the field, dig up 60cm x 30cm x 15cm deep and record white grub numbers. If total of 10 live white grubs in 5 samples, use pesticides.

Table 3. Cowpea/Niébé/Black-Eyed Pea			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	roots, damaging or killing plants.	Irrigate to speed germination and emergence of the crop. Monitor to determine where infestations are heavy. Sanitation: Destruction of plant residues from previous crops.	Use seed treated with imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) acétamipride (Titan 25 EC)
Soil pests: Wireworm (*Agriotes spp.*) (ver fil-de-fer) False Wireworms (*Gonocephalum spp.*) (faux ver fil-de-fer)	Larvae of click beetles, wireworms are red- to yellow-brown, shiny, elongate, with smooth, tough skin. They enter and feed on sown seeds, preventing germination. Damage is most likely to occur following planting into a field that had dense populations of grassy weeds.	Avoid fields with a history of wireworm damage. Use good soil tillage practices. Summer fallow will reduce wireworm numbers by drying the soil. Low-lying, sandy fields tend to have the most problems, and click beetles seem to return to the same fields to lay eggs.	Two to three weeks before planting, bury 10 untreated seeds in 5 random marked locations. Before planting, dig up the bait and check for the presence of wireworms. If a total of 5 or more wireworms are found per bait, use pesticides. use seed treated with imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments

Table 3. Cowpea/Niébé/Black-Eyed Pea			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			done only by professionals) acétamipride (Titan 25 EC)
Whitefly (*Bemisia tabaci*) (Mouche blanche)	Whiteflies are tiny, 2 mm, white, insects with piercing-sucking mouthparts. They occur in groups on the undersides of leaves, laying eggs, which develop into nymphs that also suck plant sap from the leaves. Outbreaks, leading to leaf-wilting under drought stress, often occurs when the natural biological control is disrupted by over-use of pesticides.	Do intercropping and interplanting crops Use yellow sticky traps for monitoring. After the last harvest, destroy all crop residues. Ensure good growing conditions for the crop. Avoid application of high doses of nitrogen fertilizer.	Three weeks after crop emergence, randomly sample 20 plants. Treat when 50% of plants have whiteflies. Use seed treated with imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract garlic extract chili extract acétamipride (Titan 25 EC)

Table 3. Cowpea/Niébé/Black-Eyed Pea			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			Spinosad (Laser 480 EC)
Blister beetles (*Mylabris spp.*) (Coléoptères/Scarabée cloque/ampoule)	Soft-shelled, 2-3 cm long beetles, usually black and yellow or red, that produce a toxic, burning fluid when disturbed, feed on flowers and pollen from a wide range of plant families. Adults are highly mobile and seek out plants in flower to feed, resulting in lower yield and often serious damage. It is difficult to control this pest with insecticides as the beetles feed on flowers that persist only for a day before moving to other plants.	Use tolerant varieties. Plant a trap crop of flowering plants on field margin, plow under. Avoid planting near corn fields or intercropping with it, as there is some evidence that those fields suffer heavier damage.	No treatment threshold Use seed treated with imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract
Flower thrips (*Megalurothrips sjostedti*) (Thrips des fleurs)	Thrips are tiny, 1-2mm, dark slender insects with fringed wings. They are seasonally transported northwards from Nigeria with the rain/wind storms. They feed by puncturing plant tissue and sucking out the cell contents. Nymphs and adults may damage the terminal buds and flowers, causing flower drop,	Natural enemies such as minute pirate bugs, lacewing or predatory thrips control thrips in the crop. Eliminate other host plants on or near the crop.	A threshold of 5 thrips per flower is recommended as a guideline before spraying. use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485

Table 3. Cowpea/Niébé/Black-Eyed Pea			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	leading to no seed development, which, under heavy infestation, can lead to yield losses of up to 100%.	Sanitation: Remove and destroy infested crop residues.	WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract garlic extract chili extract acétamipride (Titan 25 EC) malathion (Fyfanon 880 EC)
Pod/seed-sucking bugs (*Anoplocnemis curvipes, Clavigralla tomentosicollis, Riptortus dentipes*) (Insectes se nourrissant de la graine)	These large, 1.5-2 cm, red-brown bugs suck the sap from green pods and seeds, introducing secondary infections, leading to seed damage, shriveling and death. The fourth stage nymph causes more damage than adults. Damage is most severe when infestation occurs on young pods.	Control weeds in and around the crop.	At podding, a threshold of 2 bugs/meter row is recommended for control use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals)

Table 3. Cowpea/Niébé/Black-Eyed Pea			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			malathion (Fyfanon 880 EC) acétamipride (Titan 25 EC)
Cowpea Mosaic Virus, CPMV, transmitted by cowpea aphids (*Aphis craccivora*) (Virus de la Mosaïque porté par le puceron du Niébé)	This seed-borne virus causes green-white mottling, blistering and curling deformation of leaves, leading to reduced yield.	Rogue infected plants. Use disease-free seed Use resistant varieties. Remove alternative legume hosts. Intercropping with cereals. Use compost.	No treatment threshold Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) to control the aphid vector neem seed extract garlic extract chili extract acétamipride (Titan 25 EC)
Damping off fungi (*Rhizoctonia spp., Pythium spp., Fusarium spp.*) (Fonte des semis)	Soil-borne pathogens that infect seedlings, leading to red-brown lesions on stems and roots, causing them to wilt and die.	Use clean seed. Plant on raised-bed. Do not over-crowd plants.	No treatment threshold Use seed treated with méfenoxam

Table 3. Cowpea/Niébé/Black-Eyed Pea			
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		Obey recommendd plant spacing. Avoid water stress by planting early.	and/or difenoconazole (Ortiva Top, Apron Star 42 WS) thirame (Caiman Rouge P, Calthio Mix 485 WS, Insector T, Momtaz 45 WS--seed treatments only by professionals) neem seed extract mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP) tébuconazole + trifloxystrobin (Nativo 300 SC)
Cowpea bacterial blight (*Xanthomonas campestris pv. vignicola*) (Brûlure bacterienne du niébé)	Symptoms begin with dark, water-soaked angular spots on leaves, pods, and stems; which then enlarge into irregular necrotic lesions with yellow margins, premature leaf fall, stunting and wilting.	Use disease-free seed. Use tolerant varieties. Do intercropping. Use a 3-4-year crop rotation with nonhost plants.	No treatment threshold No bactericides are recommended

Table 3. Cowpea/Niébé/Black-Eyed Pea			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		Remove alternate cruciferous weed hosts. Control insects that make wounds. Remove and destroy crop debris after harvest.	
Charcoal rot (*Macrophomina phaseolina*) (Pourriture charbonneuse)	Charcoal rot, a soil-borne pathogen with a wide host range, produces black microsclerotia that enable it to survive adverse environmental conditions. It attacks plant stems, cotyledons and roots, leading to plant death. Tissues appear water-soaked, followed by brown, then black as microsclerotia are produced. In the absence of hosts, the microsclerotia survive in the soil for 2–15 years, depending on environmental conditions. It is one of the most important constraints to higher production,	Compost and organic soil amendments. Use tolerant varieties. Do crop rotation with cereals.	No treatment threshold Fungicide use is not recommended

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	causing an average yield loss of 10%.		
Pod rot (*Choanephora cucurbitarum*) (Pourriture brune)	Pod rot fungus attacks the withering floral parts of many plants after fertilization, from where invades cowpea pods. It can also be transmitted mechanically by insect feeding or oviposition. Infected pods appear whitish, shrink around the bulging seeds inside, and develop wet rot spots.	Compost and organic soil amendments. Use tolerant varieties. Do crop rotation with cereals.	No treatment threshold Fungicide use is not recommended
Striga/Witchweed (*Striga gesnerioides*)	Striga is a weed that parasitizes the roots of other plants, sucking nutrients from them, weakening the plants. Striga infection in cowpea is more devastating in areas with sandy soils, low fertility, and low rainfall. Striga is difficult to control because it produces large numbers of seed and up to 75% of the crop damage is done before the Striga plants emerge from the ground.	Use resistant varieties. Do crop rotation with cereals. Do intercropping.	No treatment threshold If needed, use glyphosate (Douma Woro 480 SL, Finish 68 SG, Fouralan 480 SL, Glycel 410 SL, Glyphader 75 SG, Glyphalm 360 SL, Glyphogan 480 SL, Glyphonet 360 SL, Glyphotrop 480 SL, Herbasate, Kalach/Heros 360 SL, Killer 480 SL, Mamba 360 SL, Rival 360 SL, Roundup 680

Table 3. Cowpea/Niébé/Black-Eyed Pea			
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	A major constraint that limits production in the Sahel.		Biosec, Roundup Powermax, Touchdown Forte 500 SL)
Sahel/Savannah Partridge/Quail (*Ammoperdix heyi, Alectoris philbyi*) (Perdrix Sahelien)	A small to medium-sized brown-gray bird that feeds on newly-planted seed and seedlings, often destroying an entire planting.	Use scarecrows in fields. Hang shiny metallic objects in the field. Send people to make noise and use slingshots.	No treatment threshold No avicides are recommended
Cowpea Storage Pests Bruchid Stem and Seed Weevils (*Callosobruchus maculatus, Bruchidius atrolineatus*) Greater Grain Weevil (*Sitophilus zeamais*) Larger Grain Borer (*Prostephanus truncatus*)	Small brown snout beetles, or weevils that chew into beans, nuts and seeds both in the field and in storage to feed and lay eggs. Feeding leaves grain with holes and dust (chewed pieces and frass from feeding), which ruin grain quality.	Do routine (weekly) monitoring. Train on and ensure good pest identification; understand pest biology, ecology, and behavior. Use sticky and/or pheromone traps to monitor for presence and quantity. Use hermetic grain storage systems and triple bagging technology.	Treat warehouse surfaces with chlorpyrifos-méthyl (Reldan 40 EC--only for use by professionals) Treat grain bags and grain with powdered deltaméthrine + pirimiphos-méthyl (Protect DP) or spinosad (Spintor Poudre)

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Lesser Grain Borer (*Rhyzopertha dominica*) Broad Bean Weevil (*Bruchus rufimanus*) Bean Weevil (*Acanthoscelides obtectus*) Others		Use good sanitation and good grain storage practices, as follow: Keep the warehouse well ventilated/aerated and lighted. All grain stored off the floor on pallets, with space between pallets, dispose of old containers. In empty shipping containers, thoroughly sweep or brush down walls, ceilings, ledges, braces, and handling equipment, and remove all spilled debris. Brush, sweep out and/or vacuum the truck beds, augers, and loading buckets to remove insect-infested grain and debris. Remove all debris from fans, exhausts, and aeration ducts (also from beneath slotted floors, when possible). Remove and dispose of all beans and debris remaining in planting	

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		machine or harvester, cull beans for animal feed, small piles of beans in field and close partial sacks of bean planting seed. Remove all debris from the storage site and dispose of it properly. Frequent rotation of the stocks, "FIFO" (First In - First Out) rule applies.	
Vertebrate Storage Pests Rodents: Rats, Mice Birds: Sparrows	Rodents chew on and eat stored grains, urinate and defacate on/in stored grains and grain sacks, ruining quality. Birds feed on and defacate on/in stored grains and grain sacks, ruining quality. Rats are brown-black-gray medium-size, 15-20cm, rodents.	Use good sanitation and good grain storage practices (see above). Close and fill all potential entry holes along walls, under and at door joints, at wall-ceiling joints. Can use steel wool, which rodents will not chew through. Put (preferably metal) screens on all windows. Remove all debris within a four-meter perimeter of the grain storage warehouses or	Spray around warehouse with glyphosate (Douma Woro 480 SL, Finish 68 SG, Fouralan 480 SL, Glycel 410 SL, Glyphader 75 SG, Glyphalm 360 SL, Glyphogan 480 SL, Glyphonet 360 SL, Glyphotrop 480 SL, Herbasate, Kalach/Heros 360 SL, Killer 480 SL, Mamba 360 SL, Rival 360 SL, Roundup 680 Biosec, Roundup

Table 3. Cowpea/Niébé/Black-Eyed Pea			
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	Mice are smaller, 5-10cm, brown-gray rodents. Sparrows are small, 5-10cm, gray-brown brids.	on-farm storage bins to remove rodent hiding places. Spray a ten-foot perimeter around warehouses and on-farm bins with a residual herbicide to remove all undesirable weeds that rodents use to hide. Use sticky traps for capture and disposal by burying.	Powermax, Touchdown Forte 500 SL) to remove weedy rodent hiding places. Use plastic bait boxes with brodifacoum (Vertoix Pellets) inside, placed along outer and inner walls of storage facility.

Groundnuts/Arachides/Peanuts (also cash crop)

Groundnut, *Arachis hypogaea*, was domesticated in southern Bolivia and northern Argentina, and introduded with Europeans into West Africa, where it was not adapted to local pests and diseases. Groundnut is a cash crop, protein and oil source, and has a high energy value. Africa now produces 20% of global production of groundnuts, concentrated in the Niger, Nigeria, and Mali, and is a source of nutrition and cash earnings.

Table 4. Groundnuts/Arachides/Peanuts			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Soil pest: Termites (*Coptotermes spp.*)	Termites are generally white to cream-colored, 3-7 mm, with red-brown heads. They live in a protected nest or mound and travel to crops through dried mud and saliva tubes in the soil and up trees, stalks and other vertical objects structures. The tubes protect termites from dessication. Termites feed on tree bark, often girdling twigs, branches and smaller trees, disrupting movement of nutrients and water, killing parts or the entire tree.	Use tolerant varieties. Locate and destroy termite nests and mounds near crop fields. Use healthy uninfested seeds. Use an organic and non-organic fertilizer combination to favor the growth of the seedlings.	No treatment threshold Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals)
Soil pest: White grub (*Phyllophaga spp*., *Heteronychus spp.*) (vers blancs)	White grubs, 2.5 cm long, with a red-brown head and dark gray end of abdomen, curling into a C-shape, are the immature forms of brown	Use weed management by cultivation in and around field.	In 5 places, dig up 60cm x 30cm x 15cm deep and record white grub numbers. If total of 10 white

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	scarab beetles that fly at night after first heavy rains. The larvae feed on roots, damaging or killing plants.	Avoid planting in fields that are coming out of pasture. Irrigate to speed germination and emergence of the crop. Monitor to determine where infestations are heavy. Sanitation: Destruction of plant residues from previous crops.	grubs in 5 samples, treat. use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) acétamipride (Titan 25 EC)
Soil pest: Millipedes (*Peridontopyge spp., Sdiyzonyclia spp.*) (mille-pattes)	Millipedes are long brown arthropods with two legs per body segment that feed on the root system at the collar region and cotyledons. They prefer young seedlings (< 15 days). Losses average 3-5% with an additional 5-10% due to secondary infections.	Use deep plowing. Over-seed to compensate for damage. Use crop rotation. Rake out old mulch under plants and replace it with fresh mulch or straw. No treatment threshold.	No treatment threshold No pesticides are recommended

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Soil pests: Wireworm (*Agriotes spp.*) (ver fil-de-fer) False Wireworms (*Gonocephalum spp.*) (faux ver fil-de-fer)	Larvae of click beetles, wireworms are red- to yellow-brown, shiny, elongate, with smooth, tough skin. They enter and feed on sown seeds, preventing germination. Damage is most likely to occur following planting into a field that had dense populations of grassy weeds.	Avoid fields with a history of wireworm damage. Use good soil tillage practices. Summer fallow will reduce wireworm numbers by drying the soil. Low-lying, sandy fields tend to have the most problems, and click beetles seem to return to the same fields to lay eggs.	Two to three weeks before planting, bury 10 untreated seeds in 5 random marked locations. Before planting, dig up the bait and check for the presence of wireworms. If a total of 5 or more wireworms are found per bait, use pesticides. Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) acétamipride (Titan 25 EC)

Table 4. Groundnuts/Arachides/Peanuts			
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Grasshoppers (*Acrotylus blondeli, Cataloipus cymbiferus, Cryptocatantops haemorrhoidalis, Eyprepocnemis plorans*) (sauterelles)	Adults and nymphs feed on all parts of the plant causing various degrees of defoliation.	Do weed control in crop and around field.	Threshold is 2 grasshoppers per square meter. garlic extract malathion (Fyfanon 880 EC) acétamipride (Titan 25 EC) diméthoate (Methoate 40 EC) Neem seed extract / oil
Armyworm (*Spodoptera littoralis*) (Chenilles légionnaires)	The larvae of brown migratory moths, that occur in outbreaks, these long hairless brown-green caterpillars, move and feed in groups. Larvae feed at night and hide under debris during the day. Damage first appears as skeletonized leaves, followed by irregular holes, shallow, dry wounds on pods, and finally completely defoliated plants. Eggs	Pheromone traps placed along the edges of fields may be used to monitor adult moths. Plow and harrow field thoroughly. Practice proper field sanitation: Remove weeds regularly to reduce breeding sites and shelter for armyworm.	Treat if an average of 8 or more worms is found per 3 meter-row sample. garlic extract spinosad (Laser 480 EC)

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	are laid in clusters of 50-150, and are covered in adult moth abdominal body hairs.	Destroy weeds from bordering fields and on field borders Remove all plant debris after harvesting.	BT (Batik WG, Bio K 16)
Cowpea aphid (*Aphis craccivora*) (Puceron du niébé)	This small gray/black aphid is a pest of seedlings, flowers and pods stems, petioles, terminal shoots. Often found on lower leaf surfaces and terminal buds, adults and nymphs inject a toxin that stunts growth. They extract plant sap with piercing-sucking mouthparts, and defecate honeydew onto leaves. Black sooty mold grows on this honeydew, reducing photosynthesis. Females produce 80 nymphs over an 18-day period.	Plant resistant varieties. Use crop rotation. Observe build up aphid populations and natural enemies (predators like lady bird beetles, hover flies, lacewings, parasitic wasps like *Aphidius spp*) Plant trap crops such as lupine, nasturtiums, timothy grass, anise, chives, garlic, onions, and radish near the crop to be protected. Use yellow sticky traps placed on field edges for monitoring populations.	Treat when populations are 250 aphids per plant, or when at least 80% of the plants are infested. Stop sampling once groundnuts have matured. Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals)

Table 4. Groundnuts/Arachides/Peanuts			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			neem seed extract garlic extract chili extract
Leafhopper (*Empoasca dolichi*) (Cicadelle)	This small, 5-7 mm, wedge-shaped insect is light green to yellow. Both adults and nymphs pierce and suck undersides of leaves feeding on phloem. Toxins passed into plants at feeding sites produce a symptom called hopper burn, whereby leaves yellow near the center and tips, and plant growth can be stunted, resulting in reductions in yield and grade. Damage is worse when plants are stressed, and young.	Use resistant varieties. Control weeds, especially grasses, on field margins. Create a barrier of 10m of bare ground between crop field and previously infested crops, which can reduce leafhopper movement. Provide adequate moisture through timely irrigation. Row covers can prevent leafhoppers from feeding on crops. Use intercropping.	Weekly check 20 random plants and treat when 20 percent of the leaves show tip yellowing, active adult and immature leafhoppers. use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract

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			garlic extract chili extract acétamipride (Titan 25 EC)
Thrips (*Frankliniella spp., Sericothrips spp.*)	Thrips are tiny, 1-2mm, dark slender insects with fringed wings, best viewed through a hand lens. They are seasonally transported northwards from Nigeria with the rain/wind storms. They feed by puncturing plant tissue and sucking out the cell contents. Nymphs and adults may damage the terminal buds and flowers, causing flower drop, leading to no seed development, which, under heavy infestation, can lead to yield losses of up to 100%.	Natural enemies such as minute pirate bugs, lacewing or predatory thrips control thrips in the crop. Eliminate other host plants on or near the crop. Sanitation: Remove and destroy infested crop residues.	Three weeks after crop emergence, randomly sample 20 plants per week and treat when 25 percent of the leaves show thrips damage. Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals)

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			neem seed extract garlic extract chili extract malathion (Fyfanon 880 EC) acétamipride (Titan 25 EC)
Pod borer/tomato fruitworm (*Helicoverpa armigera*) (Foreur de la gousse)	The pod borers are large caterpillars, 12-20 cm long, brown-green, with stripes on each side. They have stiff hairs on each abdominal segment that differentiate them from cutworms and armyworms. Adults are brown moths, 1.5-2 cm long. White eggs are laid individually or in small groups on both sides of leaves. High populations inflict significant damage, particularly during droughts, if larvae consume flowers and pegs during podding. Vigorously growing plants with adequate available moisture are better able to replace damaged leaves and compensate	Check for and conserve natural predators and parasites that can control large numbers of Helicoverpa larvae. Use insect pheromone traps near the field to monitor for presence, to know when to monitor for eggs. Two weeks before planting, remove weeds and grasses to destroy larvae and adults harboring in those weeds and grasses Plow, disc and harrow fields at least two times before sowing seeds to expose pupae to predators.	Treat if 12 or 3-5 larvae/m^2 are found in the vegetative or flowering-pegging stages, repectively. Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals)

Table 4. Groundnuts/Arachides/Peanuts			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	for flower and pod damage.	Sow seeds thinly and remove competing weeds to produce vigorous plants, which are more likely to withstand pests and diseases. Avoid planting crops successively that are hosts like corn, cotton, sorghum, tobacco and soybean.	neem seed extract garlic extract BT (Batik WG, Bio K 16) spniosad
Pod sucking bugs (*Rhyparochromus littoralis, Elasmolomus (=Aphanus) sordidus*) (Insecte suceurs de la gousse)	Small, 6-10 mm long, dark brown seed bugs with lighter wings, and piercing-sucking mouthparts, feed on developing groundnut pods in the field, and later in storage. Females lay their eggs (25 per day for 30 days) in the soil or on groundnut stems, dried field groundnuts, and in storage, eggs are laid loosely among the groundnut, or on sacks. In case of severe infestation, the produce is unfit for seed as well as human consumption.	Use resistant varieties. Water and fertilize seedlings to maintain vigor to resist these bugs. Control weeds in and around the crop.	No reasonable treatment threshold. neem seed extract acétamipride (Titan 25 EC)

Table 4. Groundnuts/Arachides/Peanuts			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Nematodes: Root-knot, Reniform, Sting (*Meloidogyne spp., Rotylenchulus spp., Belonolaimus spp.*) (Nématodes)	Microscopic nematodes feed within plant root zones on newly developed roots. Root-knot nematodes enter and cause galls of up to 3 cm in diameter to appear on roots as quickly as a month after planting. Reniform nematodes stick their stylet into the root, with a kidney-shaped body protruding. Sting nematodes live entirely outside the roots, feeding on root hairs, tips and edges. Nematode feeding interferes with the flow of water and nutrients to the plant, and makes wounds that act as entry points for pathogens. Infected plants are prone to wilt in hot weather, and respond poorly to fertilizer; young plants may experience reduced vigor, slow growth, and stunting.	Use resistant varieties. Do weed management in field. Use crop rotation, fallow, and intercropping, mixed cropping or cover cropping with non-host crops. Field solarization (a transparent polyethylene film is laid over moist soil for a 6-to-12-week period to heat). Flood the plot. Avoid growing on a known infected plot. Use compost to enhance soil organic matter and microbial composition. Plant Marigold (pyreuthrum flower) and plow under the soil 2 months later. Use Tithonia diversifolia as organic compost. Do “biofumigation” of the soil by growing,	No reasonable treatment threshold. fluopyram (Velum Prime 400 SC)

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		grinding/macerating and plowing under crucifers/mustards, and covering the soil with plastic, if available, until just before planting. Rotting crucifers produce toxic gasses that kill nematodes, and covering with plastic increases efficacy. Do not allow irrigation water to flow from an infested field to other fields without impounding. Prevent animal grazing and movement from infested to uninfested fields. Sanitation: Remove or compost crop residues after harvest, let them dry out before destruction. Do crop rotation to non-host or nematode-suppressing crops like pyrethrum flower, common vetch, rapeseed, Chrysanthemum, velvet bean, partridge pea, castor bean, or sesame.	

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		Soil amendments such as neem cake or castor cakes (1 tonne/ha) help reducing nematode levels	
Damping off fungi (*Aspergillus niger, Rhizoctonia solani, Rhizopus stolonifer, Fusarium spp., Pythium aphanidermatum, Sclerotium rolfsii*) (Fonte des semis)	Soil-borne pathogens that infect seedlings, leading to red-brown lesions on stems and roots, causing them to wilt and die. A major constraint that limits production in the Sahel.	Use resistant varieties. Do not over-water crop. Use recommended seeding rates; do not over-crowd plants. Use regular monitoring. Remove and destroy all plant residues. Pathogen survives well without bean hosts, so rotation will not entirely solve problem; cereal crops are the best choice.	No treatment threshold neem seed extract mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP) tébuconazole + trifloxystrobin (Nativo 300 SC)
Leaf spot fungi (Passalora (=*Cercospor)arachidicola, Phaeoisariopsis personata*) (Cercosporiose)	Leaves develop circular dark brown spots with yellow halos. Groundnuts can suffer from early and late season leaf spot fungal diseases. High humidity and warm temperatures favor disease emergence and spread of the disease is promoted by prolonged leaf wetness. Spores are	Use resistant and tolerant varieties. Use clean seed. Avoid overhead watering. Water early in the morning.	No treatment threshold mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP)

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	spread by wind, splashing rain, and insects. Several secondary disease cycles may occur per season. These fungi can produce tremendous numbers of spores on infected plant parts. Abundant peanut residue in fields where peanuts are cropped continuously often results in early and rapid development of leaf spots.	Crop rotation for 2-3 years with sorghum, maize, or fodder plants. Remove and destroy crop residues and heavily infected plants.	tébuconazole + trifloxystrobin (Nativo 300 SC) neem seed extract
Groundnut rust (*Puccinia arachidis*) (Rouille des arachides)	The disease appears as minute rust-colored flecks on both sides of the leaf. As the number of infections increase and leaves become older, they develop a rust-yellow color. Groundnut rust is highly specific to groundnuts, found on six week or older plants. Disease emergence and spread are favored by warm temperatures and nighttime condensation on the leaves. Infections may also develop on stems and leaf petioles. The severely infected	Use resistant varieties. Synchronous planting. Use intercropping. Crop rotation. Allow field to be fallow for at least one month between successive groundnut plantings. Remove any volunteer groundnut plants during fallowing to reduce inoculum.	No treatment threshold mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP) tébuconazole + trifloxystrobin (Nativo 300 SC) neem seed extract

Table 4. Groundnuts/Arachides/Peanuts			
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	leaves wither and drop prematurely.	collection and destruction of plant debris.	
Rosette Virus, RV, transmitted by Cowpea aphid (*Aphis craccivora*)	The rosette virus complex is endemic to sub-Saharan Africa. Leaf symtpoms include chlorosis, stunting, and leaf mosaic. The aphid transmits the virus within 3-10 minutes of feeding. There are two main forms of the disease: chlorotic rosette and green rosette, which are based on symptoms. Rosette epidemics are sporadic, but yield losses can approach 100% during epidemics.	Use resistant hybrids. Dense planting. Intercropping. Roguing out and disposing of infected plants away from the field.	No treatment threshold To control aphids: Use seed treated with imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract garlic extract chili extract

Table 4. Groundnuts/Arachides/Peanuts			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Peanut Clump Virus, PCV, transmitted by a fungal root infection and seed-borne	PCV infection leads to severe stunting and reduced pod setting. Mottle and chlorotic ring spots appear on new tip leaves, then disappear as leaves mature. The plant can stop growth. A yellowing strain causes concentric yellow line patterns in old leaves, but no stunting. Mottle and chlorotic ring spots appear on new tip leaves and persist, the yellow color becoming more prominent.	Use resistant/tolerant varieties. Use disease-free seed. Roguing out and disposing of infected plants away from the field.	No treatment threshold No pesticides are recommended
Bacterial wilt (*Ralstonia solanacearum*) (Flétrissement bactérien)	Leads to slight drooping or curling of leaves. Then, the plants may bend over at the tip, appear dry, and eventually turn brown, wither, and die. Discolored rotten roots and pods. Dark brown discoloration in the xylem and pith, and streaming bacterial ooze.	Use resistant/tolerant varieties. Use disease-free seed. Roguing out and disposing of infected plants away from the field.	No treatment threshold No pesticides are recommended
Groundnut Aflatoxin Molds	Yellow-green colored molds that infects groundnut pods and nuts in both the field, and in storage, usually	Use certified clean seed. Use hybrid varieties with resistance to Aspergillus.	Use non-toxin producing *Aspergillus flavus* (Aflasafe

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Aspergillus flavus and Aspergillus parasiticus	producing toxic aflatoxins.	Plant early and avoid drought stress, if possible. Control insects that damage the pod and nuts. Control fertilizer applications carefully and according to extension timing recommendations to not over-apply or apply at the inopportune time. Harvest early and on time (the longer groundnut is left in the field, the higher the aflatoxin content). Avoid or reduce pod damage during harvest. Dry and store groundnut at less than 9% moisture. Keep storage facilities clean and cool, with proper ventilation. Screen harvested pods and sample nuts for infection (see mold colors), remove and destroy (burry or burn) diseased pods.	BF 01; Aflasafe SN 01) strains developed to compete with toxin-producing strains

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Storage Pests Bruchid Grain Weevils and Borers See pest species above, under cowpea	See pest descriptions above, under cowpea	See grain storage best practices above, under cowpea	See grain treatment above, under cowpea
Vertebrae Storage Pests Rodents: Rats, Mice Birds: Sparrows	See vertebrate storage pests above, under cowpea	See vertebrate storage pests above, under cowpea	See vertebrate storage pests above, under cowpea

Maize/Corn (in field and storage, also cash crop)

Maize, *Zea mays*, was domesticated in Mexico and the Americas, after which colonists transported it to Africa, where it was not adapted to local conditions, pests and diseases, but has become a staple crop for people and livestock production.

Table 5. Maize/Corn			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Armyworms, Fall Armyworm (*Spodoptera exempta, Spodoptera frugiperda*) (Chenilles légionnaires)	The medium size, 2-3 cm, larvae of brown migratory moths, that occur in outbreaks, these long hairless brown-green caterpillars, move and feed in groups. Larvae feed at night and hide under debris during the day. Damage first appears as skeletonized leaves, followed by irregular holes, and finally defoliated plants. Eggs are laid in clusters of 50-150, and are covered in adult moth abdominal body hairs. A major constraint that limits production in the Sahel.	Pheromone traps placed along the edges of fields may be used to monitor adult moths. Plow and harrow field thoroughly. Practice proper field sanitation: Remove weeds regularly to reduce breeding sites and shelter for armyworm. Destroy weeds from bordering fields and on field borders Remove all plant debris after harvesting.	Treat if an average of 8 or more worms is found per 3 meter-row sample. Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) garlic extract spinosad (Laser 480 EC) BT (Batik WG, Bio K 16)
Stem borers (*Busseola fusca, Eldana saccharina, Sesamia calamistis*) (Foreur de tige du mais)	These small-medium, 1-2 cm, cream-pink-colored larvae of small, 1 cm, light brown moths chew through whorled leaves, producing lines of holes across the	Use resistant varieties. Plant early at the beginning of rains or within 2 weeks.	Treat when more than 15% of plants show damage.

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	leaves, followed by holes the stems, tassels and cobs, surrounded by excreta. Eggs are flat and laid in small patches under leaves. Some plants may develop deadhearts (white growing tips) which often results in profuse tillering and unproductive tillers. Late attack may result in extensive stem tunneling, the production of chaffy panicles, panicle breakage, and lodging.	Pheromone traps placed along the edges of fields may be used to monitor adult moths. Removal and destruction of deadhearts, alternate host plants and weeds in and around the field. Intercropping.	Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) spinosad (Laser 480 EC) BT (Batik WG, Bio K 16)
Corn earworm (*Helicoverpa armigera*) (Foreur de la gousse)	Medium size, 2-3 cm, smooth-skinned green-gray-brown larvae of brown moths. Moths lay eggs singly on corn ear silk, larvae feed on silk and ripening grains, leaving frass and wounds for the entry of pathogens and aflatoxins. Larvae also feed on leaves, tassels, and the whorl.	Check for and conserve natural predators and parasites that can control large numbers of larvae. Use insect pheromone traps near the field to monitor for presence, to know when to monitor for eggs. Two weeks before planting, remove weeds	No treatment threshold; monitor silks for eggs. Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T,

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		and grasses to destroy larvae and adults harboring in those weeds and grasses. Plow, disc and harrow fields at least two times before sowing seeds to expose pupae to predators. Sow seeds thinly and remove competing weeds to produce vigorous plants, which are more likely to withstand pests and diseases. Avoid planting crops successively that are hosts, like corn, cotton, sorghum, tobacco and soybean.	Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract garlic extract BT (Batik WG, Bio K 16) spinosad
Cutworm species (*Agrotis ipsilon, Agrotis segetum*) (Vers gris)	Medium, 3 cm, dark gray-brown larvae of 2 cm brown moths. Eggs are cream-white colored with ribs, laid in massed rows on weed leaves. Larvae hide under debris and in the soil during the day, feeding voraciously at night, often cutting the	Use resistant varieties (TMV-1, Staha). Use treated seed. Prepare field and remove weeds well ahead (10-14 days) of planting.	Treat with soil drench if 10% of young plants cut or damaged. Use seed treated with thiamethoxam (Apron Star 42

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	plant off, to fell it and feed on it at the soil level.	Plant sunflowers as a trap crop in or around fields. Interplant main crops with onion, garlic, peppermint, coriander, or garlic every 10-20 rows to repel cutworm. Sanitation: Destroy weeds in and around field throughout the season. Rotate to cassava, banana, sweet potato	WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract spinosad (Laser 480 EC) chilli extract garlic extract diméthoate (Methoate 40 EC) spinosad (Laser 480 EC) BT (Batik WG, Bio K 16)
Soil pest: False Wireworms *(Gonocephalum spp.)* (faux ver fil-de-fer)	Larvae of click beetles, wireworms are red- to yellow-brown, shiny, elongate, with smooth, tough skin. They enter and feed on sown seeds, preventing germination.	Avoid fields with a history of wireworm damage. Use good soil tillage practices.	Two to three weeks before planting, bury 10 untreated seeds in 5 random marked locations. Before planting,

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	Damage is most likely to occur following planting into a field that had dense populations of grassy weeds.	Summer fallow will reduce wireworm numbers by drying the soil. Low-lying, sandy fields tend to have the most problems, and click beetles seem to return to the same fields to lay eggs.	dig up the bait and check for the presence of wireworms. Treat if find a total of 5 or more wireworms per bait. Use seed treated with imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) acétamipride (Titan 25 EC)
Soil pest: White grub (*Phyllophaga spp*., *Heteronychus spp.*) (Vers blancs)	White grubs, 2.5 cm long, with a red-brown head and dark gray end of abdomen, curling into a C-shape, are the immature forms of brown scarab beetles that fly at night after first heavy rains. The larvae feed on roots, damaging or killing plants.	Use weed management by cultivation in and around field. Avoid planting in fields that are coming out of pasture. Irrigate to speed germination and emergence of the crop.	In 5 areas of the field, dig up 60cm x 30cm x 15cm deep and record white grub numbers. If total of 10 live white grubs in 5 samples, use pesticides.

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		Monitor to determine where infestations are heavy. Sanitation: Destruction of plant residues from previous crops.	use seed treated with imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) acétamipride (Titan 25 EC)
Maize black flea beetles (*Chaetocnema spp.*)	Tiny, 3-5 mm, shiny black beetles that eat tiny holes in leaves.	Parasitoids like the Braconid wasp *Microcotonus vittage* parasitize and kill adult flea beetles. Use living mulches or polycultures. Trap crops: Interplant field and margins with giant mustard or radish and destroy these plants once heavily infested. White and yellow sticky traps placed every 15 to 30 feet of row. Sanitation: Clean up and compost weeds and	One week after crop emergence, sample the field to note feeding damage by flea beetles. If the damage occurs on more than 25% of the seedlings, treat with approved pesticides. use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		plant debris from field and around field.	WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals)
Soil pest: Termites (*Coptotermes spp*.)	Termites are generally white to cream-colored, 3-7 mm, with red-brown heads. They live in a protected nest or mound and travel to crops through dried mud and saliva tubes in the soil and up trees, stalks and other vertical objects structures. The tubes protect termites from dessication. Termites feed on tree bark, often girdling twigs, branches and smaller trees, disrupting movement of nutrients and water, killing parts or the entire tree.	Use tolerant varieties. Locate and destroy termite nests and mounds near crop fields. Use healthy uninfested cuttings and seedlings. Use an organic and non-organic fertilizer combination to favor the growth of the seedlings.	No treatment threshold Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals)
Maize Leafhoppers (*Cicadulina spp.*, *Cicadulina mbila*) transmit MSV (see below)	This small, 5-7 mm, wedge-shaped insect is light green to yellow. Both adults and nymphs pierce and suck undersides of leaves feeding on phloem. Toxins passed into plants at feeding sites produce a	Control weeds, especially grasses, on field margins. Plant maize well away from previously irrigated cereals or grassland maximizes the distance	No treatment threshold. use seed treated with thiamethoxam (Apron Star 42

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	symptom called hopper burn, whereby leaves yellow near the center and tips, and plant growth can be stunted, resulting in reductions in yield and grade. Damage is worse when plants are stressed, and young.	the leafhopper needs to travel from another host. Create a barrier of 10 m of bare ground between maize fields and previously infested crops which can reduce leafhopper movement and hence MSV incidence. Removal of MSV-infected maize plants (rogueing) at an early stage. Planting a large area of maize all at once is likely to make the crop less vulnerable to maize leafhopper infestation than planting in a staggered sequence. Remove residues of maize and other cereal crops since they serve as infection sources. Do intercropping and crop rotation.	WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract garlic extract chili extract acétamipride (Titan 25 EC)

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Maize Streak Virus, MSV, transmitted by leafhopper (*Cicadulina mbila*)	Appearance on the maize leaves of many small patches about 1 mm long, pale yellow in color. By multiplying and developing, these lesions meet to form over the entire surface of the limb long irregularly interrupted chlorotic streaks arranged parallel to or on the ribs. Very sensitive plants infected early are affected with dwarfism and produce no spike.	Use resistant varieties like TMV-1, Staha-ST, Kilima-ST, Kito-ST. See leafhopper prevention, above.	No treatment threshold To control leaf hopper: Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract garlic extract chili extract acétamipride (Titan 25 EC)
Grasshoppers (various species)	Adults and nymphs feed on all parts of the plant causing	Do weed control in crop and around field.	Treat if find 8-12 grasshoppers per square meter.

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	various degrees of defoliation.		onion extract malathion (Fyfanon 880 EC) acétamipride (Titan 25 EC) diméthoate (Methoate 40 EC)
Smuts (*Ustilago maydis f. sp. zeae and Sphacelotheca reiliana*)	Initial infections from this soil-borne fungus occur on roots of young seedlings. The pathogen develops systemically and is found on ear and tassel tissues as the host plant matures. This fungus infects corn kernals, turning them bloated and gray, filled with fungal spores.	Use resistant or tolerant varieties or hybrids. Maintain soil and plant health (test these with lab tests). Rotate maize with other crops, for at least two years. Destroy smutted plant parts by removal and burning. S. Reiliana can cause damage when the season is dry and hot conditions though humid conditions.promote spore germination.	No treatment threshold Use seed treated with thirame (Caiman Rouge P, Calthio Mix 485 WS, Insector T, Momtaz 45 WS--seed treatments only by professionals) difenoconazole (Ortiva Top, Apron Star 42 WS)

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			mancozeb [6](Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP) métalaxyl[7] (Calthio mix 485 WS--seed treatments only by professionals)
Gray leaf spot (*Cercospora zeae-maydis*)	The fungus survives in debris of topsoil. Moist humid conditions favor disease development. Symptoms include long, 2-3 cm, leaf tan-gray lesions, chlorosis, and foliar blight. Entire leaves die when lesions unite.	Select moderately resistant hybrids. Do not plant maize too late. Control weeds. This will help to increase airflow and dry the canopy faster, thereby reducing the environment favorable for infection. Sanitation: Remove and destroy or compost maize stalk/leaf	No treatment threshold mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP) tébuconazole + trifloxystrobin (Nativo 300 SC)

[6] Protective fungicide seed treatment gives only reduced control, so systemic fungicides should be consider in to protective fungicide addition.

[7] Metalaxyl has a specific activity against oomycetes (e.g. Pythium, Phytophthora) and is not very effective against these fungi. Calthio mix is probably effective because of thiram, not metalaxyl.

Table 5. Maize/Corn			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		residues. Continuous maize and no-till or reduced-tillage systems are at high risk for disease development because of the amount of residue they leave on the soil surface. A one-year rotation away from maize, followed by tillage is recommended to prevent disease development in the subsequent maize crop. In no-till or reduced-till fields with a history of gray leaf spot, a two-year rotation out of maize may be needed to reduce the amount of disease in the following maize crop.	azoxystrobin (Azox, Ortiva 250 SC, Ortiva Top)
Leaf Blight *Exserohilum turcicum*	Early symptoms are oval, water-soaked spots on leaves. Mature symptoms are characteristic cigar shaped lesions that are 3 to 15cm long. Lesions are elliptical and tan in color, developing distinct dark	Use resistant or tolerant varieties. Use disease-free seed or treated seed. Sanitation: destroy infected residue.	No treatment threshold No fungicides are recommended

Table 5. Maize/Corn			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	areas as they mature that show fungal sporulation. Lesions typically appear first on lower leaves, spreading to upper leaves and the ear sheaths as the crop matures. Under severe infection, lesions may coalesce, blighting the entire leaf.	Rotate to cassava, bean, soybean, banana, vegetables.	
Rust (*Puccinia sorghi*)	The disease appears as minute rust-colored flecks on both sides of the leaf. As the number of infections increase and leaves become older, they develop a rust-yellow color. Disease emergence and spread are favored by warm temperatures and nighttime condensation on the leaves. Severely infected leaves wither and turn brown.	Use resistant varieties. Rotate maize with non-host crops. Remove and destroy crop residues.	No treatment threshold neem seed extract tébuconazole + trifloxystrobin (Nativo 300 SC) Fungicide should be applied when lesions first become visible on the lower leaves. In cool and dry seasons, fungicide application may not be cost effective

Table 5. Maize/Corn			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			particularly for grain production.
Ear rot (*Gibberella zeae (teleomorph)/ Fusarium graminearum (anamorph*)	Gibberella fungal infection leads to pink-red mold covered ears in both the field and in storage. The anamorph survives as hyphae in crop debris infected parasitically or saprophytically during crop senescence. The pathogen may be seed-borne as well as transmitted by birds and insects which favor infections also by physical injury of the plants.	Use hybrid varieties or other varieties with resistance. Use certified clean seed. Plant early and avoid drought stress, if possible. Control insects that damage the husk, ear and kernels. Control fertilizer applications carefully and according to extension timing recommendations to not over-apply or apply at the inopportune time. Harvest early and on time (the longer maize is left in the field, the higher the aflatoxin content). Avoid or reduce kernel damage during harvest. Post-harvest:	No treatment threshold neem seed extract tébuconazole + trifloxystrobin (Nativo 300 SC)

Table 5. Maize/Corn			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		Dry and store maize at less than 13% moisture. Keep storage facilities clean and cool, with proper ventilation. Screen harvested maize ears for infection (see mold colors), remove and destroy (burry or burn) diseased ears. Crop to rotate to: Rotate maize with other crops;	
Striga/Purple Witchweed (*Striga hermonthica*)	Striga is a weed that parasitizes the roots of other plants, sucking nutrients from them, weakening the plants. Striga infection in millets and sorghum is more devastating in areas with sandy soils, low fertility, and low rainfall. Striga is difficult to control because it produces large numbers of seed and up to 75% of the crop damage is done before the Striga plants emerge	Use resistant varieties. Do crop rotation with legumes. Do intercropping.	Generally, control strategies based on the use of herbicides are too expensive for low-input farming systems. If needed, glyphosate can be used

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	from the ground after parasitizing a crop root. A major constraint that limits production in the Sahel.		
Maize Weeds Many species of grasses and broadleaves	Grass weed leaves are long and thin. Broadleaf weed leaves are broad, round or ovate. Weeds outcompete the crop for soil nutrients, water and light. They can be controlled prior to planting and plant emergence, and after plant emergence.	Monitor and identify weed species present. Use fallow practices. Sanitation: To reduce seed production, disc or mow harvested fields before weeds flower and produce seeds. Cultivation equipment and irrigation water must also be kept free of weed seeds and vegetative propagules to avoid spreading weed populations. Cultivate areas around the field such as field edges, fence lines, roadsides, and irrigation ditches regularly to prevent weed seed production. To reduce seed production, disc or mow harvested fields before	If needed, use glyphosate (Koglypho 360 SL, Lamachette 360 SL, Lamachette 757 SL) If farm size served increases or is considered commercial, the project could promote or use the following 2,4-D (Binbefla Plus 720 SL, Herbexbar 720 SL, Soundiata 720 SL, Topextra 720 SL)

Table 5. Maize/Corn			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		weeds flower and produce seeds. Pre-plant plowing, followed by irrigation and one or two diskings before bed formation, will destroy many weeds. Regularly clean farm tools. Use green manure that chokes out weeds. Use intercropping. Hand weeding during their earlier growing period. Do not let the weeds flower (do not compost weeds that have flowered and set seed). Hoeing, mowing, and cutting.	2,4-D diméthylamine (Calliherbe 720 SL, Dekade, Sun-2,4D Amine 720) nicosulfuron (Akizon 40 SC, Akoumais 40 SC, Kababin 40 SC, Maia 75 WG, Maia Super, Nico Top 40 AD, Nicodaf 40 SC, Nicokaba 40 SC, Nicomais 40 SC, Niconet 40 SC, Nicosuper 40 SC, Segaibaana 40 SC, Sofa 40 SC) pendiméthaline (Alligator, Pendaf 500 EC, Pendinet 500 EC, Pendistar, Penditrop 500 EC,

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			rimsulfuron (Ricomais 25 WG Saphir)
Maize Ear and Kernel Aflatoxin Molds in the field and in storage *Aspergillus flavus and Aspergillus parasiticus*	Yellow-green colored molds that infects maize ears and kernals in both the field, and in storage, usually producing toxic aflatoxins.	Use certified clean seed. Use hybrid varieties with resistance to Aspergillus. Plant early and avoid drought stress, if possible. Control insects that damage the husk, ear and kernals. Control fertilizer applications carefully and according to extension timing recommendations to not over-apply or apply at the inopportune time. Harvest early and on time (the longer maize is left in the field, the higher the aflatoxin content).	Use non-toxin producing *Aspergillus flavus* (Aflasafe BF 01; Aflasafe SN 01) strains developed to compete with toxin-producing strains

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		Avoid or reduce kernel damage during harvest. Dry and store maize at less than 13% moisture. Keep storage facilities clean and cool, with proper ventilation. Screen harvested maize ears for infection (see mold colors), remove and destroy (burry or burn) diseased ears.	
Invertebrate Storage Pests Grain Weevils See grain storage pest species above, under cowpea	See grain storage pest descriptions above, under cowpea	See grain storage best practices above, under cowpea	Treat grain bags and grain with powdered pirimiphos-méthyl + perméthrine (Actellic Super Dust, Antouka 19 DP) or pirimiphos-méthyl + thiamethoxam (Actellic Gold Dust) or spinosad (Laser 480 EC) (Spintor Poudre)

Table 5. Maize/Corn			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Vertebrate Grain Storage Pests Rodents: Rats, Mice Birds: Sparrows	See vertebrate grain storage pests above, under cowpea	See vertebrate grain storage pests above, under cowpea	See vertebrate grain storage rodenticide above, under cowpea

Millets/Sorghum (in field and storage)

Pearl millet, *Pennisetum glaucum*, is the only cereal crop well adapted to the Sahelian arid region and is a major subsistence food crop in the Niger, the world's top producer per capita of millet. In many areas, production of millet beyond the immediate family needs provides an important source of cash income for poorer households. Sorghum, *Sorghum bicolor*, domesticated in north-eastern Africa near the Sudan-Egypt border, and improved in the highlands of Ethiopia as well as the semi-arid Sahel, and is also well adapted to Africa's pests and diseases. Both crops are used as food and cash crops, are drought and heat tolerant, high yielding, easy to weed, and do not require use of synthetic fertilizers.

They are especially important in arid regions, where the grains are staples for rural and poorer people. They are also a source of fodder for cattle, sheep, and goats and stems are used as building materials for dwellings and fencing. Millet is more drought tolerant than sorghum and is therefore preferred by farmers, although sorghum can produce higher yields. Both corps are cultivated in rows and intercropped together with legumes such as cowpea and groundnut in the traditional cropping systems that have shown resilience in the face of drought, poor soil, and minimal fertilizer in the form of animal manures.

Table 6. Millets/Sorghum			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Millet head miner (*Heliocheilus albipunctella*) (La chenille mineuse de l'épi)	The larvae of a small-medium, 1-1.5 cm, brown moth. After hatching, caterpillars feed and complete their larval development within the panicle. The early larval instars eat into individual florets; larger larvae consume peduncles, destroying developing grains, and creating mines around the rachis. Full-grown caterpillars are pink. When mature, they drop to the ground, where they burrow into the soil to pupate. A major constraint that limits production in the Sahel.	On-farm augmentative releases of the parasitoid *Habrobracon hebetor* are being used successfully. Early maturing variety and plant early. Tolerant variety (such as varieties with long bristles).	Treat panicles when miners are found on more than 15% of panicles neem seed extract garlic extract spinosad (Laser 480 EC)
Armyworms (*Spodoptera exempta, S. littoralis, Spodoptera exempta,*	The larvae of brown migratory moths, that occur in	Pheromone traps placed along the edges	Treat if an average of 8 or more worms is

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S. frugiperda, Mythimna loreyi) (Chenilles légionnaires)	outbreaks, these long hairless brown-green caterpillars, move and feed in groups. Larvae feed at night and hide under debris during the day. Damage first appears as skeletonized leaves, followed by irregular holes, shallow, dry wounds on pods, and finally completely defoliated plants. Eggs are laid in clusters of 50-150, and are covered in adult moth abdominal body hairs. A major constraint that limits production in the Sahel.	of fields may be used to monitor adult moths. Plow and harrow field thoroughly. Practice proper field sanitation: Remove weeds regularly to reduce breeding sites and shelter for armyworm. Destroy weeds from bordering fields and on field borders Remove all plant debris after harvesting.	found per 3 meter-row sample. use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) garlic extract spinosad (Laser 480 EC) BT (Batik WG, Bio K 16)
Seed bugs (*Dysdercus volkeri, Oedaleus senegalensis, Eurystylus oldi, Creontiades pallidus, Agonoscelis versicolor, Spilostethus spp*.) (Insectes suceurs de la graine)	Long, 1-1.5 cm, red-yellow-black bugs that feed on plant seeds. They feed by injecting digestive saliva and using piercing-sucking	Use resistant varieties. Water and fertilize seedlings to maintain vigor to resist these bugs.	No treatment threshold

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	mouthparts to suck up dissolved seed contents. Microorganisms also enter the feeding wound, further damaging the seed. A major constraint that limits production in the Sahel.	Control weeds in and around the crop.	neem seed extract acétamipride (Titan 25 EC)
Soil pest: White grub (*Phyllophaga spp*., *Heteronychus spp.*) (Vers blancs)	White grubs, 2.5 cm long, with a red-brown head and dark gray end of abdomen, curling into a C-shape, are the immature forms of brown scarab beetles that fly at night after first heavy rains. The larvae feed on roots, damaging or killing plants.	Use weed management by cultivation in and around field. Avoid planting in fields that are coming out of pasture. Irrigate to speed germination and emergence of the crop. Monitor to determine where infestations are heavy. Sanitation: Destruction of plant residues from previous crops.	In 5 areas of the field, dig up 60cm x 30 x 15cm deep and record white grub numbers. If total of 10 live white grubs in 5 samples, use pesticides. Use seed treated with imidaclopride (Calthio Mix 485 WS, Insector T,

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			Momtaz 45 WS--all seed treatments done only by professionals) acétamipride (Titan 25 EC)
Soil pest: wireworms (*Agriotes* spp.) (Ver fil-de-fer)	Larvae of click beetles, wireworms are red- to yellow-brown, shiny, elongate, with smooth, tough skin. They enter and feed on sown seeds, preventing germination. Damage is most likely to occur following planting into a field that had dense populations of grassy weeds.	Avoid fields with a history of wireworm damage. Use good soil tillage practices. Summer fallow will reduce wireworm numbers by drying the soil. Low-lying, sandy fields tend to have the most problems, and click beetles seem to return to the same fields to lay eggs.	Two to three weeks before planting, bury 10 untreated seeds in 5 random marked locations. Before planting, dig up the bait and check for the presence of wireworms. If a total of 5 or more wireworms are found per bait, use pesticides. Use seed treated with imidaclopride (Calthio Mix 485 WS, Insector T,

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			Momtaz 45 WS--all seed treatments done only by professionals) acétamipride (Titan 25 EC)
Stem borers: Millet (*Coniesta ignefusalis*) (Foreur de tige du mil) Sorghum (*Busseola fusca, Eldana saccharina, Sesamia calamistis*) (Foreur du Sorgho)	These cream-pink-colored larvae of small, 1 cm, light brown moths chew through whorled leaves, producing lines of holes across the leaves, followed by holes the stems, tassels and cobs, surrounded by excreta. Eggs are flat and laid in small patches under leaves. Some plants may develop deadhearts (white growing tips) which often results in profuse tillering and unproductive tillers. Late attack may result in extensive stem tunneling, the production of chaffy panicles, panicle	Plant early at the beginning of rains or within 2 weeks. Early planting (appropriate planting dates should be decided based on local infestation levels). Removal and destruction of deadhearts and alternate host plants. Intercropping. Biological control with *Trichogramma*, as available from the government.	Treat when more than 15% of stems show damage. Spray individual panicles at panicle exsertion: neem seed extract spinosad (Laser 480 EC)

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	breakage, and lodging.		
Grain midges: Millet (*Geromyia penniseti*) (Cécidomyie du mil) Sorghum (*Stenodiplosis (=Contarinia) sorghicola*)	A tiny, 2-3 mm, fly, the larvae/maggots of which feed on developing grains causing grainless glumes with a white pupal case attached to the tip of the spikelet.	Use resistant varieties. Early planting. Plant so that all fields flower synchronously, within 10-15 days.	No treatment threshold neem seed extract garlic extract spinosad (Laser 480 EC) acétamipride (Titan 25 EC)
Millet flower scarab and blister beetles (*Rhinyptia infuscate*, *Psalydolytta fusca*, *P. vestita*) (Coléoptères de la fleur du mil) (Coléoptères/Scarabée cloque/ampoule)	Soft-shelled, 2-3 cm long beetles, usually black and yellow or red, that produce a toxic, burning fluid when disturbed, feed on flowers and pollen from a wide range of plant families. Adults are highly mobile and seek out plants in flower to feed, resulting in lower yield and often serious damage. It is difficult to control this pest with insecticides as the	Use tolerant varieties. Plant a trap crop of flowering plants on field margin, plow under.	No treatment threshold Use seed treated with imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals)

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	beetles feed on flowers that persist only for a day before moving to other plants.		neem seed extract acétamipride (Titan 25 EC)
Shoot fly (*Atherigona soccata*) (M ouche des pousses)	A tiny, 7-8 mm, fly, the larvae/maggots of which feed on the growing point of the shoot of the seedling. The result is a typical "dead heart". Usually the attack results in tillering. When the outbreak is severe, tillers may also be attacked. Eggs are laid on the underside of the leaves of 7 8 days old seedlings, or on young tillers. One to three eggs are laid per leaf.	Early planting. Synchronous planting between fields in a community. Good nutrient management. The Introduction of larval parasite *Telenomus spp* by the government could effectively control this pest.	Treat if 5 locations of 3 row-meters are over 15% infested. Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract garlic extract

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			acétamipride (Titan 25 EC)
Spittlebugs (*Locris rubens, Poophilus costalis*) (Cercopes)	Small, 4-5mm, light green bugs that surround themselves in a characteristic frothy secretion to protect themselves as they feed on all above-ground parts of the plant, using piercing-sucking mouthparts. Feeding symptoms include yellow leaf blotching. Severe infestations often kill young leaves and plants.	Use resistant varieties. Water and fertilize seedlings to maintain vigor to resist these bugs. Control weeds in and around the crop.	No treatment threshold neem seed extract acétamipride (Titan 25 EC)
Leaf beetle (*Lema planifrons*) (Chrysomèle)	Small, 4-5mm, brown beetle, the larvae of which feed on leaves, skeletonizing them.	Water and fertilize seedlings to maintain vigor to resist these beetles. Parasitoids like the Braconid wasp *Microcotonus vittage* parasitize and kill adult leaf beetles. Use living mulches or polycultures.	No reasonable treatment threshold Use seed treated with imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45

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		Trap crops: Interplant field and margins with giant mustard or radish and destroy these plants once heavily infested. White and yellow sticky traps placed every 15 to 30 feet of row for monitoring. Sanitation: Clean up and compost weeds and plant debris from field and around field.	WS--all seed treatments done only by professionals) neem seed extract acétamipride (Titan 25 EC)
Grasshoppers (*Acrotylus blondeli, Cataloipus cymbiferus, Cryptocatantops haemorrhoidalis, Eyprepocnemis plorans*) (sauterelles)	Adults and nymphs feed on all parts of the plant causing various degrees of defoliation.	Do weed control in crop and around field.	Threshold is from 8 to 12 grasshoppers per square meter. garlic extract malathion (Fyfanon 880 EC) acétamipride (Titan 25 EC)

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			diméthoate (Methoate 40 EC)
Downy mildews: Downy mildew of pearl millet (*Sclerospora graminicola*) (Mildiou du Mil) Downy mildew or sorghum (*Peronosclerospora sorghii*) (Mildiou du Sorgho)	Symptoms depend on host, climatic conditions and time of infection. Generally, this fungus produces characteristic chlorosis at the leaf base, and white mats of spores on the undersides of leaves. Seed heads can show malformed bushy tissue growth. Late season infection may lead to dwarfing. A major constraint that limits production in the Sahel.	Use resistant varieties. Use seed treatments and clean seed. Intercropping. Roguing within the first month after sowing; bury infected plants. Crop rotation. Early sowing. Improved crop nutrient fertilization. Deep tillage.	No treatment threshold Use seed treated with métalaxyl (Calthio mix 485 WS--seed treatments only by professionals) difenoconazole (Ortiva Top, Apron Star 42 WS) mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP)
Damping off fungi (*Pythium spp. Rhizoctonia spp.*) (Fonte des semis)	Soil-borne pathogens that infect seedlings, leading to red-brown lesions on stems	Use seed treatments and clean seed. Plant on raised-bed.	No treatment threshold

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	and roots, causing them to wilt and die.	Obey proper spacing; do not crowd plants. Avoid water stress by planting early.	Use seed treated with thirame (Caiman Rouge P, Calthio Mix 485 WS, Insector T, Momtaz 45 WS--seed treatments only by professionals) difenoconazole (Ortiva Top, Apron Star 42 WS) neem seed extract
Charcoal rot (*Macrophomina phaseolina*) (Pourriture charbonneuse)	Charcoal rot, a soil-borne pathogen with a wide host range, produces black microsclerotia that enable it to survive adverse environmental conditions. It attacks plant stems,	Use resistant hybrids. Eliminate low areas in the field and improve drainage to prevent development of stalk rot. Good water management to avoid stressing plants,	No treatment threshold Use seed treated with thirame (Caiman Rouge P,

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	cotyledons and roots, leading to plant death. Tissues appear water-soaked, followed by brown, then black as microsclerotia are produced. In the absence of hosts, the microsclerotia survive in the soil for 2–15 years, depending on environmental conditions.	particularly as the crop approaches the flowering stage. Crop rotation to nonhost crops, such as small grains, can also help reduce the disease potential. Practice balanced fertility (do not over-fertilize, especially with nitrogen). Practice sanitation: plowing crop residues under at the end of the season. Avoid excessive plant density	Calthio Mix 485 WS, Insector T, Momtaz 45 WS--seed treatments only by professionals)
Gray leaf spot (*Cercospora sorghi*) (Maladie des taches rectangulaires)	The fungus survives in debris of topsoil. Moist humid conditions favor disease development. Symptoms include long, 2-3 cm, leaf tan-gray lesions, chlorosis, and foliar blight. Entire leaves	Use resistant varieties. Intercropping. Crop rotation. Remove plant residues after harvest. Remove adventitious weedy grasses.	No treatment threshold mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP)

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	die when lesions unite.		tébuconazole + trifloxystrobin (Nativo 300 SC) azoxystrobin (Azox, Ortiva 250 SC, Ortiva Top)
Sorghum leaf blight (*Exserohilum (=Helminthosporium) turcicum*) (Helminthosporiose)	Early symptoms are oval, water-soaked spots on leaves. Mature symptoms are characteristic cigar shaped lesions that are 3 to 15cm long. Lesions are elliptical and tan in color, developing distinct dark areas as they mature that show fungal sporulation. Lesions typically appear first on lower leaves, spreading to upper leaves and the ear sheaths as the crop matures. Under severe infection, lesions may coalesce, blighting the entire leaf.	Use resistant varieties. Use disease-free seed. Intercropping. Crop rotation. Remove plant residues after harvest.	No treatment threshold Use seed treated with thirame (Caiman Rouge P, Calthio Mix 485 WS, Insector T, Momtaz 45 WS--seed treatments only by professionals) mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP,

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			Manga Plus, Ivory 80 WP) tébuconazole + trifloxystrobin (Nativo 300 SC)
Anthracnose (*Colletotrichum graminicola*) (Pourriture rouge)	A seed-borne fungus that infects leaves, stems, and panicle. Infection appears as oval purple leaf and stalk spots, followed by red-purple lesions on the rachis and panicle branches.	Use resistant varieties. Remove or plow under and destroy crop residues. Rotate with non-cereals.	No treatment threshold Use seed treated with thirame (Caiman Rouge P, Calthio Mix 485 WS, Insector T, Momtaz 45 WS--seed treatments only by professionals) mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP)

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			tébuconazole + trifloxystrobin (Nativo 300 SC)
Ergot (*Claviceps sorghi, C. fusiformis*)	Fungal damage is characterized by light pink sticky droplets oozing out of infected panicle florets. These droplets dry and harden, turning into dark brown to black sclerotia. The sclerotia are larger than seed and irregularly shaped, and can become mixed with the grain during threshing. High humidity and temperatures favor disease development. The sclerotia germinate when the plants are flowering, produce spores that are blown onto flowers, where they invade the young kernels. These spores can also be carried by insects or	Use resistant varieties. Use clean seeds. When certified seed is not available, a method to separate the seed from contaminating sclerotia consists in immersing them in a water solution of NaCl (100 g/L). The sclerotia will float and can be easily harvested. Remove and destroy infected panicles. Remove or deep plow under and destroy crop residues and fungal sclerotia. Rotate with non-cereals.	No treatment threshold fungicides are not recommended

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	splashed by rain to infect other kernels.		
Rough leaf spot (*Ascochyta sorghi*) (Maladie des grains de sable)	This fungus produces small red spots on leaves, which enlarge, elongate, turn purple and rough.	Use resistant varieties. Rotate with non-cereals. Remove or plow under and destroy crop residues.	No treatment threshold neem seed extract
Smuts: Long smut (*Tolyposporium ehrenbergii*) (Charbon allongé du sorgho) Covered kernel smut (*Sporisorium sorghi*) (Charbon couvert du sorgho) Loose kernel smut (*Sphacelotheca cruenta*) (Charbon nu) HEAD SMUT (*SPHACELOTHECA REILIANA, SYN. SPORISORIUM*	These fungi infect grasses, and can infect portions of the panicle or destroy all kernels in a head and replace them with a cone-shaped gall. At harvest time, these galls usually break, releasing spores to contaminate the outer surface of other kernels. This damage appears as malformed panicles and grain heads.	Use resistant varieties. Use clean seed. Control weeds. Rotate with non-cereals.	No treatment threshold Use seed treated with thirame (Caiman Rouge P, Calthio Mix 485 WS, Insector T, Momtaz 45 WS--seed treatments only by professionals) difenoconazole (Ortiva Top,

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HOLCI-SORGHI) (CHARBON DE LA PANICULE)			Apron Star 42 WS) mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP) métalaxyl[8] (Calthio mix 485 WS--seed treatments only by professionals) Azoxystrobin (Azox, Ortiva 250 SC, Ortiva Top)
Millet rust (*Puccinia penniseti, P. purpurea*) (Rouille du mil, sorgho)	These diseases appear as minute rust-colored flecks on both sides of the	Use resistant varieties. Use clean seed.	No treatment threshold

[8] Metalaxyl has a specific activity against oomycetes (e.g. Pythium, Phytophthora) and is not very effective against these fungi. Calthio mix is probably effective because of thiram, not metalaxyl.

Table 6. Millets/Sorghum			
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	leaf. As the number of infections increase and leaves become older, they develop a rust-yellow color. Disease emergence and spread are favored by warm temperatures and nighttime condensation on the leaves. Severely infected leaves wither and turn brown.	Plant early. Control weeds. Rotate with non-cereals.	Use seed treated with difenoconazole (Ortiva Top, Apron Star 42 WS) neem seed extract chlorothalonil (Jumper 75 WG) mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP) tébuconazole + trifloxystrobin (Nativo 300 SC)
Striga/Purple Witchweed (*Striga hermonthica*)	Striga is a weed that parasitizes the roots of other plants, sucking nutrients from them, weakening the plants. Striga infection in millets and sorghum is	Use resistant varieties. Do crop rotation with legumes. Do intercropping.	Note that control strategies based on the use of herbicides are too expensive for low-input

Table 6. Millets/Sorghum			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	more devastating in areas with sandy soils, low fertility, and low rainfall. Striga is difficult to control because it produces large numbers of seed and up to 75% of the crop damage is done before the Striga plants emerge from the ground after parasitizing a crop root. A major constraint that limits production in the Sahel.		farming systems. If needed, glyphosate can be used
Invertebrate Storage Pests Grain Weevils See grain storage pest species above, under cowpea	See grain storage pest descriptions above, under cowpea	See grain storage best practices above, under cowpea	See invertebrate storage insecticides above, under maize
Vertebrate Storage Pests	See vertebrate storage pests	See vertebrate storage pests above, under cowpea	See vertebrate storage rodenticide

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Rodents: Rats, Mice Birds: Sparrows	above, under cowpea		above, under cowpea

Solanaceous Crops (garden and cash crops): Potato/Irish Potato; Tomato; Peppers (hot/sweet); Eggplant

Potatoes, *Solanum tuberosum*, originated in the highlands of South America, and were introduced by Europeans to East Africa, where they were not adapted to the local conditions, pests and diseases, and spread from there to other parts of Africa. Potato can be grown in a wide variety of soil types, except heavy, waterlogged clay soils; good drainage is of great importance to managing diseases and tuber rots.

Tomatoes, *Solanum lycopersicum*, are native to South and Central America, and were introduced to the Middle East, from where they spread to most of Africa, where they were not adapted to local conditions, diseases and pests. Now, tomatoes are the most popular vegetable in the Sudano-Sahel, for use in salads and sauces. Thye are grown for home consumption and are an important source of vitamins and an important cash crop for both smallholders and medium-scale commercial farmers.

Peppers and chili peppers, *Capsicum species*, also native to South America, were brought by Europeans to West Africa, where they were not adapted to local conditions, diseases and pests. There are five species of chili peppers used for spice and food. Chili peppers are much more prominent than sweet peppers in the cuisines in West Africa. Many dishes are enriched with a base of tomatoes, onions and chili peppers, considered as a starter for cooking many dishes. Chili can be used to help preserve food, as well as add flavor to relatively bland tropical carbohydrate staples. Most peppers are consumed and some is exported.

The eggplant, or aubergine, *Solanum melongena*, was domesticated in India and was introduced by Europeans to the Mediterranean and Africa, where it was not adapted to local conditions, pests and diseases. Eggplant varieties grown in West Africa are smaller, more bitter, white-yellow, and most commonly referred to as garden eggs. Eggplant is used widely in West Africa, where it is chopped, cooked and mixed into a variety of vegetable dishes, meat and fish dishes and sauces. It is mostly grown in home gardens for local consumption.

Table 7. Solanaceous Crops (garden and cash crops): Potato/Irish Potato; Tomato; Peppers (hot/sweet); Eggplant			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Soil pest: Mole cricket (*Gryllotalpa africana*) (Taupe-grillon)	Mole cricket adults are 22-28 mm long, brown in color with have short wings folded over their abdomens. They are especially active during the rainy season. They tunnel in the root and tuber zones to feed and lay eggs. During warm, humid nights, they dig tunnels close to the surface and come out of the tunnels at night to feed on leaves and stems. Feeding on tubers allows secondary infection to occur, which further degrades tubers. Mole crickets are particularly damaging to recently planted tubers; their feeding can kill the developing potato plant.	Use weed management by cultivation in and around field. Use light traps when adults are present. Irrigate to speed germination and emergence of the crop. Monitor to determine where infestations are heavy. Sanitation: Destruction of plant residues from previous crops and avoiding planting in fields that are coming out of pasture.	No treatment threshold use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals)
Soil pest: Termites (*Coptotermes spp*.)	Termites are generally white to cream-colored, 3-7 mm, with red-brown heads. They live in a protected nest or mound and travel to crops through dried mud and saliva tubes in the soil and up trees, stalks and other vertical objects structures. The	Use tolerant varieties. Locate and destroy termite nests and mounds near crop fields.	No treatment threshold Use seed treated with thiamethoxam (Apron Star 42

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	tubes protect termites from dessication. Termites feed on tree bark, often girdling twigs, branches and smaller trees, disrupting movement of nutrients and water, killing parts or the entire tree.	Use healthy uninfested cuttings and seedlings. Use an organic and non-organic fertilizer combination to favor the growth of the seedlings.	WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals)
Cutworms (*Agrotis ipsilon*) (Vers gris)	Medium, 3 cm, gray-brown larvae of 2 cm brown moths. Eggs are cream-white colored with ribs, laid in massed rows on weed leaves. Larvae hide under debris and in the soil during the day, feeding voraciously at night, often cutting the plant off, to fell it and feed on it at the soil level.	Check for and conserve natural predators and parasites that can control large numbers of cutworms. Use insect pheromone traps near the field to monitor for presence, to know when to monitor for eggs. Two weeks before planting, remove weeds and grasses to destroy larvae and adults harboring in those weeds and grasses. Plow, disc and harrow fields at least two	Treat with soil drench if 10% of young plants cut or damaged. Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals)

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		times before sowing seeds to expose pupae to predators. Sow seeds thinly and remove competing weeds to produce vigorous plants, which are more likely to withstand pests and diseases. Avoid planting crops successively that are hosts, like corn, cotton, sorghum, tobacco and soybean.	neem seed extract spinosad (Laser 480 EC) chilli extract garlic extract diméthoate (Methoate 40 EC) BT (Batik WG, Bio K 16)
Aphids (*Myzus persicae, Macrosiphum euphorbiae, Aulacorthum solani, Aphis gossypii*) (Pucerons)	Many aphid species attack Solanaceous crops. Aphids are mainly found on young shoots and on the underside of leaves. Aphids use piercing-sucking mouthparts to remove plant sap, and are most important as vectors of viruses.	Use resistant varieties Use regular monitoring with yellow sticky traps Many natural enemies and pathogens control these aphids under low insecticide use. Sanitation: Field disking and destruction of crop residues are important for control of aphid pests of leafy	No treatment threshold Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed

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		vegetables to reduce their migration into nearby crops.	treatments done only by professionals) neem seed extract garlic extract chili extract
Armyworms (*Spodoptera exempta; S. frugiperda*) (Chenilles légionnaires)	The larvae of brown migratory moths, that occur in outbreaks, these long hairless brown-green caterpillars, move and feed in groups. Larvae feed at night and hide under debris during the day. Damage first appears as skeletonized leaves, followed by irregular holes, shallow, dry wounds on pods, and finally completely defoliated plants. Eggs are laid in clusters of 50-150, and are covered in adult moth abdominal body hairs.	Pheromone traps placed along the edges of fields may be used to monitor adult moths. Plow and harrow field thoroughly. Practice proper field sanitation: Remove weeds regularly to reduce breeding sites and shelter for armyworm. Destroy weeds from bordering fields and on field borders	Treat if an average of 8 or more worms is found per 3 meter-row sample. use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		Remove all plant debris after harvesting.	only by professionals) garlic extract spinosad (Laser 480 EC) BT (Batik WG, Bio K 16)
Tuber moth, on potato (*Phthorimaea operculella*) (Teigne de la pomme de terre)	Potato tuber moth is small, 12mm, and widely distributed. It is the most serious pest of potatoes in the region. It attacks all solanaceous crops, both in fields and storage. While damage to leaves does not usually damage productivity, root and tuber feeding can be devastating. Tunnels are brown and full of frass, leading to infection by microorganisms. The moths are small, 12mm, brownish grey with narrow fringed wings, and are active mainly at dusk. Female moths lay eggs singly or in small batches near potato eye buds on exposed tubers or through cracks in the soil, or on foliage. Larvae pupate on the soil surface or under crop debris in the field. If not	Store tubers in 20cm deep dry soil after drying in the sun. Crop rotation. Removal of volunteer sprouts from field. Use of healthy, clean seed. Avoid planting in hard soil. Plant as deeply as possible (10cm deep). Ridge at least three times during the growing season.	No reasonable treatment threshold Use seed treated with imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) BT (Batik WG, Bio K 16) (especially for stored potatoes)

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	controlled before, or in storage, all tubers can become damaged.	Ensure compact hilling. Provide enough water to prevent soil cracks. Mulch the plants with straw. Harvest the crop immediately as it matures. At harvesting select and store only uninfested tubers, chose a cool place, keep storage clean. Bag and remove all harvested tubers before late afternoon every day. Destroy all infested potatoes immediately and remove all plant residues. Conserve natural enemies. In the field and storage, monitor with pheromone traps.	

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		Store tubers in cool or refrigerated storage.	
African bollworm (*Helicoverpa armigera*) (Foreur de la gousse)	Bollworms are large caterpillars, 12-20 cm long, brown-green, with stripes on each side. They have stiff hairs on each abdominal segment that differentiate them from cutworms and armyworms. Adults are brown moths, 1.5-2 cm long. White eggs are laid individually or in small groups on leaves. High populations inflict significant damage, particularly during droughts, if larvae consume flowers and pegs during podding. Vigorously growing plants with adequate available moisture are better able to replace damaged leaves and compensate for flower and pod damage.	Check for and conserve natural predators and parasites that can control large numbers of Helicoverpa larvae. Use insect pheromone traps near the field to monitor for presence, to know when to monitor for eggs. Two weeks before planting, remove weeds and grasses to destroy larvae and adults harboring in those weeds and grasses. Plow, disc and harrow fields at least two times before sowing seeds to expose pupae to predators. Sow seeds thinly and remove competing weeds to produce vigorous plants, which are more likely to	No reasonable treatment threshold Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract garlic extract BT (Batik WG, Bio K 16) spinosad

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		withstand pests and diseases. Avoid planting crops successively that are hosts, like corn, cotton, sorghum, tobacco and soybean.	
Tomato leaf miner (*Tuta absoluta*)	This newly-introduced larva of a small, 4-5mm, silver-brown moth disperses on the wind and people carrying infested fruits when they travel. Damage is characterized by many small mines in leaves, stems and fruit. The moth reproduces rapidly, with a life cycle ranging from 24-38 days, depending on temperature. One female may deposit up to 250-260 eggs during her life on aboveground plant parts. There are 4 instars that take 8 days to develop before pupation. Young larvae have white or cream colored bodies with a black head, turning pink or green. Larvae mine in leaf tissues, in stems, and on fruit, often destroying it, before pupating in the soil.	Allow a minimum of 6 weeks from crop destruction to planting the next crop to prevent carryover of the pest from previous crop. Between planting cycles, cultivate the soil and cover with mulch. Control weeds to prevent multiplication in alternative weed host (especially Solanum, Datura). Use pest-free transplants. Place pheromone-baited traps to monitor all stages of tomato	No reasonable treatment threshold Use seed treated with imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) spinosad (Laser 480 EC) BT (Batik WG, Bio K 16)

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	They are most active during night.	production, i.e. nurseries, farms, packaging, processing and distribution centers. Remove and destroy all host plants of Tuta Crop to rotate to: Rotate to cereals, cassava, sweet potato, soybean, haricot, banana	neem seed extract garlic extract acétamipride (Titan 25 EC)
Whitefly (*Bemisia tabaci*)	Whiteflies are tiny, 2 mm, white, insects with piercing-sucking mouthparts. They occur in groups on the undersides of leaves, laying eggs, which develop into nymphs that also suck plant sap from the leaves. Outbreaks, leading to leaf-wilting and death under drought stress, often occurs when the natural biological control is disrupted by over-use of pesticides.	Do intercropping and interplanting crops Use yellow sticky traps on field margins for monitoring. After the last harvest, destroy all crop residues. Ensure good growing conditions for the crop. Avoid application of high doses of nitrogen fertilizer.	Monitor yellow sticky traps for sudden surges in catches, to treat. Use seed treated with imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals)

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			Tagetes oil + thyme oil (Marigold) neem seed extract garlic extract chili extract acétamipride (Titan 25 EC) spinosad (Laser 480 EC)
Mediterranean fruit fly (*Ceratitis capitata*)	The adult medfly is 0.4 cm long which is about 2/3 the size of a housefly. The general color of the body is yellowish with a tinge of brown, especially the abdomen, legs, and some of the markings on the wings. Damage to crops include oviposition in fruit and soft tissues of vegetative parts of certain plants, feeding by the larvae, and decomposition of plant tissue by invading secondary microorganisms. Fruit fly females lay eggs under the epidermis of the fruit. Several eggs may be laid on each fruit. Maggots remain in	Use resistant varieties. Removal of fruit as it matures. Sanitation: Clean up and destroy heavily infested fruit at least twice a week, burn or bury at least 50cm deep. Pick overripe fruits, as they attract fruit flies. Physical methods include fruit fly traps.	No reasonable treatment threshold neem seed extract garlic extract acétamipride (Titan 25 EC) spinosad (Laser 480 EC)

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	fruits until fully grown (from 2 to 3 weeks), after which they drop to the soil to pupate.		diméthoate (Methoate 40 EC) malathion (Fyfanon 880 EC)
Leaf miner (*Liriomyza trifolii*)	Leaf miners attack a wide variety of vegetable crops, particularly in the seedling stage, often grown in proximity to cole crops. Adults are tiny black flies with a bright yellow spot on their thorax. Females puncture leaves to feed on plant sap and lay eggs within the leaf tissues. After 2 to 4 days, the eggs hatch and larvae feed between the upper and lower surface of leaves, as they move in their tunnels. Larvae emerge from the leaf mines and pupate on the leaf surface or, more commonly, drop from the plants to land in cracks in the soil. Many generations may occur each year, and the entire life cycle can be completed in less than 3 weeks when the weather is warm. Leaf miners can reduce the plant's photosynthetic capacity, render edible leaf portions unmarketable, and	Use yellow and green sticky traps to monitor and reduce populations. Use microtunnel covers to exclude leaf miners. Conserve natural enemies. Parasitic wasps normally control leaf miners, if not killed by pesticide overuse. Rotate with non-host crops and plan the arrangement of fields so that old infested fields do not provide a reservoir of infestation for subsequent crops. Destroy leaf miner pupae in the soil by plowing and tilling, by solarization, and, on	No reasonable treatment threshold use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract garlic extract acétamipride (Titan 25 EC)

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	provide an entrance for pathogenic organisms.	heavy soils, by flood irrigation.	spinosad (Laser 480 EC)
Thrips: Tobacco thrips (*Thrips tabaci*) especially on pepper Flower thrips (*Frankliniella spp., Sericothrips spp.*)	Thrips are tiny, 1-2mm, dark slender insects with fringed wings. They are seasonally transported northwards from Nigeria with the rain/wind storms. They feed by puncturing plant tissue and sucking out the cell contents. Nymphs and adults may damage the terminal buds and flowers, causing flower drop, leading to no seed development, which, under heavy infestation, can lead to yield losses of up to 100%.	Natural enemies such as minute pirate bugs, lacewing or predatory thrips control thrips in the crop. Eliminate other host plants on or near the crop. Sanitation: Remove and destroy infested crop residues.	No reasonable treatment threshold Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract garlic extract chili extract

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			acétamipride (Titan 25 EC) malathion (Fyfanon 880 EC)
False codling moth/shoot borer (*Thaumatotibia (=Cryptophlebia) leucotreta*) especially on pepper and eggplant	The larvae of this small moth, 1 cm, have been recorded feeding on more than 50 species of plants in over 30 families. The eggs are deposited on the surface of the host fruit over irregular intervals throughout the female's life. Once hatched from the eggs the larvae burrow into the fruit. A discoloration appears at the wound site as a sign that secondary microorganisms have entered the wound. Larvae pupate in a silken cocoon in the soil, or under leaf litter.	Control by collecting and destroying all damaged and fallen fruit.	No treatment threshold Use seed treated with imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) BT (Batik WG, Bio K 16)
Leafhoppers (*Empoasca spp.*) (Cicadelle) especially on eggplant	This small, 5-7 mm, wedge-shaped insect is light green to yellow. Both adults and nymphs pierce and suck undersides of leaves feeding on phloem. Toxins passed into plants at feeding sites produce a symptom called hopper burn, whereby leaves yellow near the	Use resistant varieties. Control weeds, especially grasses, on field margins. Create a barrier of 10m of bare ground between crop field and	No treatment threshold Use seed treated with thiamethoxam

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	center and tips, and plant growth can be stunted, resulting in reductions in yield and grade. Damage is worse when plants are stressed, and young.	previously infested crops, which can reduce leafhopper movement. Provide adequate moisture through timely irrigation. Row covers can prevent leafhoppers from feeding on crops. Use intercropping.	(Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract garlic extract chili extract acétamipride (Titan 25 EC)
Leaf caterpillar (*Selepa docilis*) (Chenille de la feuille) especially on eggplant	This larva of this brown moth with white hind wings are pale green in color and covered with long gray hairs. Usually the larvae feed in small groups to defoliate the plants close to where the eggs were laid. Eggs are laid singly near the leaf edge. The larvae feed on the leaves removing all but the main veins. Pupation occurs on	Hand remove egg masses. Remove and destroy weeds early in the crop cycle.	No treatment threshold Use seed treated with imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--

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	cocoons on the leaves. Many generations are produced per year. Larvae feed voraciously and skeletonize the leaves leaving only the larger veins.		all seed treatments done only by professionals) BT (Batik WG, Bio K 16) neem seed extract diméthoate (Methoate 40 EC)
Mites: Red spider mite (*Tetranychus spp.)* Broad mite or chili mite (*Polyphagotarsonemus (= Hemitarsonemus*) *latus*)	Mites are tiny 8-legged acarids that feed with piercing mouthparts, in groups on leaf undersides. Spider mites usually produce webbing to protect themselves. Extensive feeding causes leaf wilt and death, and is exacerbated by warm dry weather and drought. Broad mites are oval-shaped, seen by hand lens. A generation takes about 1 week under optimal conditions and females deposit 40 eggs. Dispersal is by winds and on the bodies of other insects especially whiteflies. Broad	Install windbreaks around the field. Leave a distance (10m) between the crop and the field borders. Do weed control in and around the field. Remove crop residues after harvest several times at 10-day intervals. Conserve natural enemies (like predatory mites and anthocorid bugs) by	Three weeks after crop emergence, randomly sample 20 plants weekly. Treat when 30% of leaves show mite presence. neem seed extract garlic extract chili extract abamectine (Abalone 18 EC, Acarius 18 EC,

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	mite toxic saliva causes twisted, hardened and distorted growth at the terminal of the plant. Mites are usually seen on the newest leaves and small fruit. Severely infected fruits fall, and yield is significantly reduced.	avoiding use of broad spectrum pesticides. Provide good growing conditions for plants as healthy plants are more likely to withstand mite attack. Adequate irrigation. Apply mulch and incorporate organic matter into the soil to improve the water holding capacity and reduce evaporation.	Bomec 18 EC, Vertimec 18 EC)
Nematodes: Root Knot (*Meloidogyne spp.*) (Nématode à galles) Sting nematode (*Belonolaimus longicaudatus*) (Nématode piquant)	Microscopic nematodes feed within plant root zones on newly developed roots. Root-knot nematodes enter and cause galls of up to 3 cm in diameter to appear on roots as quickly as a month after planting. Nematode feeding interferes with the flow of water and nutrients to the plant. Infected plants are prone to wilt in hot weather, and respond poorly to fertilizer; young plants may experience reduced vigor, slow growth, and stunting. Sting nematodes live entirely outside	Use resistant varieties. Do weed management in field. Use crop rotation, fallow, and intercropping, mixed cropping or cover cropping with non-host crops. Field solarization (a transparent polyethylene film is laid over moist soil for	No reasonable treatment threshold. fluopyram (Velum Prime 400 SC)

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	the roots, feeding on root hairs, tips and edges. Nematode feeding interferes with the flow of water and nutrients to the plant, and makes wounds that act as entry points for pathogens. Infected plants are prone to wilt in hot weather, and respond poorly to fertilizer; young plants may experience reduced vigor, slow growth, and stunting.	a 6-to-12-week period to heat). Flood the plot. Avoid growing on a known infected plot. Use 2 kilos of compost per plant to enhance soil organic matter and microbial composition. Plant Marigold (pyreuthrum flower) and plow under the soil 2 months later. Use Tithonia diversifolia as organic compost. Do “biofumigation” of the soil by growing, grinding/macerating and plowing under crucifers/mustards, and covering the soil with plastic, if available, until just before planting. Rotting crucifers produce toxic gasses that kill nematodes, and covering with	

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		plastic increases efficacy. Do not allow irrigation water to flow from an infested field to other fields without impounding. Prevent animal grazing and movement from infested to uninfested fields. Sanitation: Remove or compost crop residues after harvest, let them dry out before destruction. Do crop rotation to non-host or nematode-suppressing crops like pyrethrum flower, common vetch, rapeseed, Chrysanthemum, velvet bean, partridge pea, castor bean, or sesame.	
Bacterial wilts (*Ralstonia =(Pseudomona)*	Bacterial wilt causes rapid wilting and death of the entire plant without any yellowing or	Plant resistant varieties. Use certified disease-free seed.	No treatment threshold

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solanacearum) (Flétrissement/ Pourriture molle bactérien)	spotting of leaves. The pathogen is transmitted through tuber seed into the soil. Also, infected soil can be important source of disease infection. Internal parts of the stem turn brown.	In potatoes, if possible avoid cutting seed tubers Control root-knot nematodes since they could facilitate infection and spread of bacterial wilt. Soil amendments (organic manures) can suppress bacterial wilt pathogen in the soil. Disinfect farming equipment and soil on tractor tires and workers' boots. Remove wilted plants from the field to reduce spread of the disease from plant to plant. Avoid continuous planting of Solanaceous crops. Post-harvest decay can be reduced by harvesting fruits when dry, minimizing injury during handling, and	neem seed extract garlic extract fluopyram (Velum Prime 400 SC) for nematodes

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		storage at cool temperatures. Do not grow solanaceous crops in soil where bacterial wilt has occurred. Rotate with beans or maize.	
Bacterial spot (*Xanthomonas campestris pv. vesicatoria*)	The bacteria, which is seed-borne, transplant- borne, as well as surviving in crop debris, attack leaves, fruit and stems. Circular, sunken and water-soaked leaf spots become necrotic with brown centers surrounded by yellowish borders, which can turn yellow and drop. Stem spots are elongated. Fruits develop wart-like raised brown spots. The disease spreads rapidly during warm, rainy conditions. Long periods of high relative humidity with free moisture on leaves favors infection. Infections are favored by temperatures above 20° C.	Use indexed pathogen-negative seed, treated seed, or disease-free transplants. Planting and growth: Use furrow or drip irrigation. Destroy crop residues. For at least one year, rotate away from Solanaceous crops.	No treatment threshold neem seed extract garlic extract

Table 7. Solanaceous Crops (garden and cash crops): Potato/Irish Potato; Tomato; Peppers (hot/sweet); Eggplant			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Bacterial soft rot (*Erwinia carotovora*) (Pourriture molle bactérienne)	Infection by this bacteria causes tubers to putrefy in the field and storage. Latent infection can lead to non-emergence of plants, chlorosis, wilting, desiccation of the tops of stems, and typical soft rot. Infected vines release bacteria to the soil and the bacteria can move to new tubers through soil water. The pathogen is carried within diseased potato tubers or other plant debris, but it is usually dormant and does not cause disease symptoms unless environmental conditions are favorable. In storage, soft rot spreads easily but must enter through mechanical wounds or fungal infections. Wet tubers having free water on the surface are very prone to soft rot infection.	Use certified disease-free propagation material. Use resistant or tolerant varieties. Do not plant after potatoes or cabbage. Do weed control in and around the field. Plant in well-drained soils. Avoid over-irrigation. Use deep well water for irrigation. Monitor for early detection, remove, place in a plastic bag and destroy/burn/burry diseased plants away from the field, throughout the season. Control other pests which produce wounds through which this bacterium enters the plant.	No treatment threshold neem seed extract garlic extract

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		Harvest when the field is dry, minimize handling injury, use proper cool and dry storage. Disinfect pruning and harvesting tools between plants, as well as gloves, boots and clothing used. Remove and destroy all strings, lines and plant/fruit supports which may have come into contact with the bacteria leaking from infected fruits. If peppers require washing, add some chlorine to the water. Crop to rotate to: Beans or maize.	
Stem rot (*Sclerotium rolfsii*) (Pourriture de la tige)	Affected stems on plants with stem rot first show a moist decay at or slightly below the soil surface where infection is initiated. Stem lesions expand up and down the stem, and leads to wilting and yellowing of foliage. The fungus persists in	Sterilize seedbed soil. Time planting to allow plants to emerge rapidly.	No treatment threshold Use seed treated with: thirame (Caiman Rouge P, Calthio Mix

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	soil between crops. The fungus quickly grows over the tuber surface and invades, resulting in a moist cheesy decay. The fungus can invade dead vines as well as living ones. Extensive tuber losses can be initiated within a few days of harvest if the fungus is present, and rot can continue in transit. Hot temperatures and moist soil surfaces favor germination and infection by dormant spores. In pre-emergence damping-off, the seed rots in the soil or the seedling dies before it emerges. In post-emergence damping-off the seedling topples over after it has emerged from the soil but while it is still small and succulent. The plant collapses because the stem tissues at or near the ground level become soft and water-soaked.	Uproot all residue plants and destroy by burning. Restrict movement in field. *S. rolfsii* attacks many field and vegetable crops (including leguminous and crucifer crops), so rotations are not 100% effective but may be used though the choice of crops to rotate with is limited.	485 WS, Insector T, Momtaz 45 WS--seed treatments only by professionals) neem seed extract mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP)
Early blight (*Alternaria solani*) (Alternariose)	Symptoms include black spots with yellow borders on leaves, then larger brown spots. Spots are circular, up to 12 mm in diameter. On fruit, spots start	Use resistant varieties. Disinfect seeds.	No reasonable treatment threshold

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	at the attachment point, and spread. Lesions are usually slightly sunken, circular or irregular, with a well-defined and sometimes slightly raised margin between healthy and diseased tissue. Internally, the tissue becomes brown to black corky, dry rot. Deep cracks may form in older lesions. Early blight thrives best under warm wet conditions.	Use a crop rotation of 3-4 years. Avoid watering the foliage at the end of the day or at night. Do not plant new fields near existing fields with blight symptoms. If possible, use furrow irrigation. Remove and destroy crop debris.	Use seed treated with: thirame (Caiman Rouge P, Calthio Mix 485 WS, Insector T, Momtaz 45 WS--seed treatments only by professionals) garlic extract mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP) tébuconazole + trifloxystrobin (Nativo 300 SC)
Late blights (*Phytophthora infestans; Phytophthora capsici, and Phythophthora*	These fungal diseases are favored by cool, cloudy, wet conditions. Symptoms of late blight are irregular, greenish-black, water soaked patches, which appear on the leaves. The spots soon turn brown and	Sterilize seedbed soil. Time planting to allow plants to emerge rapidly.	No treatment threshold Proper management late blights require a relatively large

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parasitica)-especially on eggplant (Mildiou)	many of the affected leaves wither, yet frequently remain attached to the stem. On fruits, tissues darken, become lumpy and hard to the touch. These diseases are spread by movement of infested soil from nursery to field, including on workers' boots and equipment, and by cultivation practices, so restrict the movement in field. It is favoured by moist, crowded conditions in seedbeds and boxes. In field-raised seedlings, wet conditions favour disease, avoid these favoured conditions.	Uproot all residue plants and destroy by burning. Restrict movement in field. Avoid rotating to Solanaceae plants. Make sure transplants are free of the disease. Avoid overhead irrigation if possible.	number of AIs, including both contact and systemic fungicides. Azoxystrobin (Azox, Ortiva 250 SC, Ortiva Top) Chlorothalonil (Jumper 75 WG) metalaxyl (Calthio mix 485 WS--seed treatments only by professionals) Mefenoxam (Ortiva Top, Apron Star 42 WS) Use seed treated with: thirame (Caiman Rouge P, Calthio Mix 485 WS, Insector T, Momtaz 45 WS--seed treatments only by professionals)

Table 7. Solanaceous Crops (garden and cash crops): Potato/Irish Potato; Tomato; Peppers (hot/sweet); Eggplant			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP)
Common scab disease on potato (*Streptomyces scabies*) (Gale commune)	This disease is caused by a filamentous bacterium which is a saprophyte that can survive for long periods on decaying organic matter, in the absence of hosts. Tubers are susceptible as soon as they are formed and infections occur while they are still on the ground. A mature tuber with a healthy skin set is no longer susceptible to new infection by the pathogen. Scab symptoms are most notable at harvest or later in the season. The pathogen enters through wounds and pores in the epidermis of young developing tubers, and stimulates the growth of corky tissue. Lesions	Use resistant cultivars or varieties. Use certified seed tubers free from common scab. Use land leveling and maintain high soil moisture (80–90% of available water storage) during tuber initiation and the 6 to 8 weeks that follow. Use crop rotation with green manure crops such as rye, millet, and oats (rotations with carrots, beets, spinach, turnip, and	No treatment threshold mancozeb [9](Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP)

[9] Fungicide is minimally effective in controlling this bacteria-like organism in the soil. Control should rely more heavily on correct agronomical practices.

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	expand as the tubers expand. Such lesions spoil the appearance of the tubers and cause wastage in peeling and reduction in grade.	radish are not advisable). Avoid soil application of animal wastes, which favors scab development. Before planting, apply sulfur and triple superphosphate to decrease soil pH. No single measure effectively controls this disease, thus it is necessary to use a combination of the indicated preventive measures.	
Fungal Charcoal rot (*Macrophomina phaseolina*)	Charcoal rot, a soil-borne pathogen with a wide host range, produces black microsclerotia that enable it to survive adverse environmental conditions. It attacks plant stems, cotyledons and roots, leading to plant death. Tissues appear water-soaked, followed by brown, then black as microsclerotia are produced. In the absence of hosts, the microsclerotia survive in the soil	Sterilize seedbed soil. Time planting to allow plants to emerge rapidly. Uproot all residue plants and destroy by burning. Restrict movement in field. Avoid rotating to Solanaceae plants,	No treatment threshold Use seed treated with: thirame (Caiman Rouge P, Calthio Mix 485 WS, Insector T, Momtaz 45 WS--seed treatments only by professionals)

Table 7. Solanaceous Crops (garden and cash crops): Potato/Irish Potato; Tomato; Peppers (hot/sweet); Eggplant			
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	for 2–15 years, depending on environmental conditions.	due to Macrophomina phaseolina having a a broad host range including leguminous, cucurbits and other crops therefore the selection of crops to use in rotations must be very careful selected as it is not sufficient to rotate with any non-solanaceous crop.	neem seed extract mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP)
Damping off fungi (*Pythium spp., Fusarium spp., Fusarium oxysporum f. sp. Lycopersici*)	Soil-borne pathogens that infect seedlings, leading to red-brown lesions on stems and roots, causing them to wilt and die. In pre-emergence damping-off, the seed rots in the soil or the seedling dies before it emerges. In post-emergence damping-off the seedling topples over after it has emerged from the soil but while it is still small and succulent. The plant collapses because the stem tissues at or near the	Sterilize seedbed soil. Time planting to allow plants to emerge rapidly. Uproot all residue plants and destroy by burning. Restrict movement in field. Avoid rotating to Solanaceae plants.	No treatment threshold Use seed treated with: thirame (Caiman Rouge P, Calthio Mix 485 WS, Insector T, Momtaz 45 WS--seed treatments only by professionals)

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	ground level become soft and water-soaked.		neem seed extract mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP) tébuconazole + trifloxystrobin (Nativo 300 SC)
Anthracnose (*Colletotrichum coccodes; Colletotrichum melongenae*)	This fungus generally infects green, ripe or overripe fruit and roots of mature plants. The fungus can penetrate the cuticle of uninjured fruit. When green fruit is infected, it does not show spotting until it begins to ripen. On ripe fruit, lesions become visible within 5 to 6 days after infection. The fungus survives the dry season as sclerotia and hyphae in infested crop debris. At the start of the rainy season the lower leaves and fruit may become infected by germinating sclerotia and spores in the soil debris. Infections of the lower leaves are important sources of spores	Use resistant cultivars. Use disease-free seed and seedlings. Sanitation: Throughout season remove diseased seedlings. Control weeds and solanaceous weeds in field. Manage water moisture and avoid planting in water-logged soil.	No treatment threshold azoxystrobin (Azox, Ortiva 250 SC, Ortiva Top) trifloxystrobin chlorothalonil (Jumper 75 WG) difenoconazole (Ortiva Top, Apron Star 42 WS) tébuconazole +

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	for secondary infections throughout the growing season. Dead leaves with early blight infections and isnect feeding damage leaves are invaded by Anthracnose, which produces new spores.		trifloxystrobin (Nativo 300 SC)
Powdery mildew (*Leveillula = Oidiopsis taurica*)	This wind/rain transmitted fungal infection is characterized by a gray-white powdery film, yellow-brown spots on the leaves and stems, which become dry and brittle. The leaves will then turn yellow, die and drop off. Severe infections result in sunburned fruits and weakened plants. Infected plants have lower yield and a shortened fruiting season. High relative humidity and warm, shady weather favors disease development.	The first line of defense is disease-free seedlings. Destroy whole plan and root after harvest. Use resistant varieties Use natural and plastic soil mulches. Follow strict field sanitation. Remove solanaceous weeds. Practice rotation with non-solanaceous crops (minimum 5 years).	No treatment threshold neem seed extract tébuconazole + trifloxystrobin (Nativo 300 SC)

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Cercospora leaf spot (*Pseudocercospora* (=*Cercospora abelmoschi*) (Cercosporiose) especially on eggplant	A fungal disease transmitted by wind, rain and irrigation water is characterized by tiny circular or oval spots on leaves that enlarge with time. It is also seed-borne. Dark green or brown round spots surrounded by a yellow ring form on young plants, but turn white on older crop. Leaves turn yellow then wilt and fall. Elongated spots form on stems. The disease is favored by dew, rain and high humidity.	Use resistant and tolerant varieties. Use clean seed. Avoid overhead watering. Water early in the morning. Crop rotation for 2-3 years with sorghum, maize, or fodder plants. Remove and destroy crop residues and heavily infected plants.	No treatment threshold mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP) tébuconazole + trifloxystrobin (Nativo 300 SC) neem seed extract
Viruses: Potato Leaf Roll Virus (PLRV), Potato X Virus (PXV), Potato Virus Y (PVY)	Symptoms include leaf puckering, mottling discoloration, and dwarfing. Aphids transmit these viruses**.** Under field conditions, there is often a composite infection with the three viruses (PLRV; PVX; PVY) on potato. PLRV also infects other solanaceous crops and weeds. The virus spreads early in the season, as young plants are generally more susceptible. Plants that are infected early become more efficient sources for further	Use resistant varieties. Use clean and treated seed.	No treatment threshold To control aphids: Use seed treatments of imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed

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	virus spread than plants infected later in the season. Fruits/tubers are generally smaller.		treatments done only by professionals) neem seed extract
Tomato leaf yellow curl virus, TYLCV, transmitted by white fly on tomato, pepper	This virus causes leaves to turn yellow and curl. TYLCV can spread rapidly, over short distances flown by the vector. Over long distance, the virus is primarily spread through the movement of infected plants, especially tomato transplants. Because it can take up to 3 weeks for disease symptoms to develop, infected symptomless plants are unknowingly transported. Plants infected at an early stage will have their growth severely stunted, and not bear fruit.	Use resistant varieties. Use clean and treated seed.	Use seed treated with imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals)
Cucumber Mosaic Virus, CBMV, transmitted in a non-persistent fashion by aphids (*Aphis gossypii, Myzus persicae*) (Virus de la Mosaïque du	Leaves turn mosaic with light to dark green patches, with some fraying. Flowers can fall and fruits become bumpy or wrinkled, sometimes with yellow to black rings. Aphids can acquire CBMV from an infected plant in 10 to 30	Use resistant varieties. Use clean and treated seed.	No treatment threshold To control aphids:

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Concombre) on tomato, pepper	seconds and transmit the virus after feeding for as few as 9 seconds.		Use seed treatments of imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract
Tobacco/Tomato Mosaic Virus, TMV, transmitted mechanically and on seed/plant cuttings on tomato, pepper	Symptoms of plants infected with TMV vary with the cultivar and the specific virus strain. A mild mosaic develops on leaves with some leaf malformation, including a fernlike appearance. TMV is transmitted mechanically and there are many sources of the virus, including tobacco products, tomato seed, infected plant debris, and cultivation equipment.	Use resistant varieties. Use clean and treated seed.	No treatment threshold No pesticides are recommended
Pepper Veinal Mottle Virus (PVMV) is transmitted in the non-persistent manner by aphids *Myzus persicae*	Common symptoms include leaf curling. PVMV can be acquired by aphids and inoculated within 2 minutes of feeding and is not seed borne.	Use resistant varieties. Use clean and treated seed.	No treatment threshold

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and *Aphis gossypii*, especially on pepper	High temperature and dry weather favor the pathogen.		To control aphids: Use seed treatments of imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract

Soybean/ Soya, for chicken food (high-value cash export crop for organic chicken feeds in Europe)

Soybean, *Glycine max*, originated in China and was spread from there by Europeans to Africa, where it was not adapted to local conditions, pests or diseases. It is grown for human consumption as cooking oil, cooked pods, and processed products. Soybean is also grown as food for chickens. It can grow in a wide range of soils, with optimum growth in moist alluvial soils with a good organic matter content, rare in much of West Africa.

Table 8. Soybean/ Soya, for chicken food			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Armyworms (*Spodoptera exempta, Spodoptera frugiperda*) (Chenilles légionnaires)	The larvae of brown migratory moths, that occur in outbreaks, these long hairless brown-green caterpillars, move and feed in groups. Larvae feed at night and hide under debris during the day. Damage first appears as skeletonized leaves, followed by irregular holes, shallow, dry wounds on pods, and finally completely defoliated plants. Eggs are laid in clusters of 50-150, and are covered in adult moth abdominal body hairs.	Pheromone traps placed along the edges of fields may be used to monitor adult moths. Plow and harrow field thoroughly. Practice proper field sanitation: Remove weeds regularly to reduce breeding sites and shelter for armyworm. Destroy weeds from bordering fields and on field borders Remove all plant debris after harvesting.	Treat if an average of 8 or more worms is found per 3 meter-row sample. use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) spinosad (Laser 480 EC) BT (Batik WG, Bio K 16)
Flower Thrips (*Frankliniella spp., Sericothrips spp.*) (Thrips des fleurs)	Thrips are tiny, 1-2mm, dark slender insects with fringed wings. They are seasonally transported northwards from Nigeria with the rain/wind storms. They feed by puncturing plant tissue and sucking out the cell contents. Nymphs and adults may damage the terminal buds and	Natural enemies such as minute pirate bugs, lacewing or predatory thrips control thrips in the crop.	A threshold of 5 thrips per flower is recommended as a guideline before spraying. Use seed treated with thiamethoxam

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	flowers, causing flower drop, leading to no seed development, which, under heavy infestation, can lead to yield losses of up to 100%.	Eliminate other host plants on or near the crop. Sanitation: Remove and destroy infested crop residues.	(Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract garlic extract chili extract acétamipride (Titan 25 EC) malathion (Fyfanon 880 EC)
Green stinkbugs (*Nezara viridula*) (Punaise verte)	Green stinkbugs are small-medium, 1-1.5cm, pentagon-shaped, and feed on all above-ground plant parts with piercing-sucking mouthparts, and transmit bacterial infections. They inject a toxic saliva into the tissues, to dissolve them, with direct destruction of the tissues. Barrel-shaped ggs are laid in neat parallel rows on plant parts, 30-130 per mass. Growing shoots and developing fruit are preferred.	Use resistant varieties. Water and fertilize seedlings to maintain vigor to resist these bugs. Control weeds in and around the crop.	A threshold of 2-3 bugs/meter row is suggested. Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T,

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	Shoots usually wither or, in extreme cases, may die. Puncture damage on fruit appears as hard brownish or black spots, which lower its market value. Young fruit growth is retarded. Fruit often withers and drops from the plant.		Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract malathion (Fyfanon 880 EC) diméthoate (Methoate 40 EC) acétamipride (Titan 25 EC)

Sweet potato

Sweet potatoes, *Ipomoea batatas*, are perennial vines domesticated in tropical America. It is widely grown mainly in subsistence farming and currently gaining popularity again along with other indigenous foods. The roots are eaten either boiled or roasted alone or with other foods such as milk, soups or meat. Roots are sometimes prepared in a porridge that might also include cowpea, lima bean, sesame, and/or millet. There has been some development in recent years of sweet potato snacks, such as chips sold in urban markets. Young leaves are used as vegetable and are high in protein. And, the sweet potato vines are a useful and nutritious fodder crop, especially in the dry season.

Table 9. Sweet potato			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Sweet potato weevils (*Cylas puncticollis, C. brunneus*) (Charançon de la patate douce)	Two species of weevils are involved: Cylas puncticollis (shiny black adult) and C. brunneus (several colors). The sweet potato tuber is the preferred site for feeding and egg laying by adults, but in the beginning of the season, adult weevils feed on leaves and stems, while larvae bore into and directly damage the tuber. If roots with egg punctures are stored, they will serve as a source of infestation for the clean roots stored beside them. Infested tubers are often riddled with cavities or tunnels and eventually rot. Feeding in the vines causes thickening and malformation, often cracking of the tissue, discoloring it and causing wilting. Damage to the stems may cause serious mortality to seedlings. A major constraint that limits production in the Sahel.	Use resistant varieties. Use un-infested planting material, especially vine tips, as weevils tend to lay eggs in woody, older parts of the vines. Site new plantings away from previous sweet potato fields. Select <30 cm lengths from the tips of vines as planting material. Destroy crop residues after harvest by burning or feed to livestock. Remove volunteer plants and alternate hosts. Crop rotation on a cycle of 3 years.	No reasonable treatment threshold Use vine piece treatment with imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) spinosad (Laser 480 EC) acétamipride (Titan 25 EC)
Aphids (*Aphis gossypii, Myzus persicae, Aulacorthum solani*) (Pucerons de patate douce)	Aphids attack terminal leaves, flower heads, and stems. Infested plants develop yellow foliage, may become dwarfed and malformed, and lose vigor. Symtoms include stunted, wilted and discolored plants, leaves curl downward and pucker. Heavily infested plants turn brown and die from the top down. Aphids produce sticky	Use resistant varieties Use regular monitoring with yellow sticky traps Many natural enemies and pathogens control these aphids under low insecticide use. Sanitation: Field disking	No treatment threshold Use vince piece treatment with imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--

Table 9. Sweet potato			
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	honeydew on which grows black sooty mold, blocking sunlight and photosynthesis. A major constraint that limits production in the Sahel.	and destruction of crop residues are important for control of aphid pests of leafy vegetables to reduce their migration into nearby crops.	all seed treatments done only by professionals) neem seed extract garlic extract chili extract
Chrysomelid leaf beetles (*Aulacophora similis* and *Monolepta semiviolacea*)	Small, 5-8mm, brightly colored beetles that chew holes in leaves. Eggs are laid in the soil. Larvae live in the soil, feeding on roots.	Use fast-growing varieties that can out-grow damage. Avoid planting new crops next to those already infested with the beetles. Provide conditions for healthy rapid plant growth, especially for cuttings; these may include use of manures, mulches, commercial fertilizers, as well as adequate water. Sanitation: After harvest, collect and destroy the vines.	No treatment threshold No insecticides are recommended

Table 9. Sweet potato			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Plataspid stink bug/Lablab bug (*Megacopta cribraria*)	A small, 3-7mm, round-square shaped brown-olive colored bug that feeds, using piercing-sucking mouthparts, on leaves and stems. Eggs look like little oblong barrels, and are laid in two parallel lines. Nymphs are light green. Nymphs and adults congregate in large numbers under leaves and on stems.	Collect and kill bugs when they congregate for diapause.	No treatment threshold Use vine piece treatment with imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) acétamipride (Titan 25 EC)
Whiteflies (*Bemisia tabaci*) (Mouche blanche)	Whiteflies are tiny, 2 mm, white, insects with piercing-sucking mouthparts. They occur in groups on the undersides of leaves, laying eggs, which develop into nymphs that also suck plant sap from the leaves. Outbreaks, leading to leaf-wilting and death under drought stress, often occurs when the natural biological control is disrupted by over-use of pesticides.	-Intercropping. -Put insect-proof nets to protect the nursery. -Yellow sticky traps reduce populations. -Water regularly the foliage. -Conserve natural enemies such as parasitic wasps and predators (predatory mites, ladybird beetles, and lacewings). -After the last harvest,	Prior to fruit development monitor 20 plants weekly, especially on field margins. Treat if 40% of leaves average at least 3 adults. Use seed piece treatment with imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed

Table 9. Sweet potato			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		destroy all crop residues.	treatments done only by professionals) neem seed extract garlic extract chili extract spinosad (Laser 480 EC)
Sweet potato hornworm (*Agrius convolvuli*) (Sphinx de la patate douce)	These large, 4-5cm, green larvae eat large irregular holes on leaves, leading to defoliation.	-Handpick caterpillars from leaves (especially in small areas). -Turn the soil over between crops. -Monitor populations with light traps.	Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) spinosad (Laser 480 EC) BT (Batik WG, Bio K 16)

Table 9. Sweet potato			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Armyworms (*Spodoptera exempta, Spodoptera frugiperda*) (Chenilles légionnaires)	The larvae of brown migratory moths, that occur in outbreaks, these long hairless brown-green caterpillars, move and feed in groups. Larvae feed at night and hide under debris during the day. Damage first appears as skeletonized leaves, followed by irregular holes, shallow, dry wounds on pods, and finally completely defoliated plants. Eggs are laid in clusters of 50-150, and are covered in adult moth abdominal body hairs.	Pheromone traps placed along the edges of fields may be used to monitor adult moths. Plow and harrow field thoroughly. Practice proper field sanitation: Remove weeds regularly to reduce breeding sites and shelter for armyworm. Destroy weeds from bordering fields and on field borders Remove all plant debris after harvesting.	Treat if an average of 8 or more worms is found per 3 meter-row sample. Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) garlic extract spinosad (Laser 480 EC) BT (Batik WG, Bio K 16)
Root knot nematode (*Meloidogyne spp.*) (Nématode à galles)	Microscopic nematodes feed within plant root zones on newly developed roots. Root-knot nematodes enter and cause galls of up to 3 cm in diameter to appear on roots as quickly as a month after planting. Nematode	Use resistant varieties. Do weed management in field. Use crop rotation, fallow, and intercropping, mixed	No reasonable treatment threshold. fluopyram (Velum

Table 9. Sweet potato			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	feeding interferes with the flow of water and nutrients to the plant. Infected plants are prone to wilt in hot weather, and respond poorly to fertilizer; young plants may experience reduced vigor, slow growth, and stunting.	cropping or cover cropping with non-host crops. Field solarization (a transparent polyethylene film is laid over moist soil for a 6-to-12-week period to heat). Flood the plot. Avoid growing on a known infected plot. Use 2 kilos of compost per plant to enhance soil organic matter and microbial composition. Plant Marigold (pyreuthrum flower) and plow under the soil 2 months later. Use Tithonia diversifolia as organic compost. Do “biofumigation” of the soil by growing, grinding/macerating and plowing under crucifers/mustards, and covering the soil with plastic, if available, until just before planting. Rotting crucifers produce toxic gasses that kill nematodes, and covering	Prime 400 SC)

Table 9. Sweet potato			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		with plastic increases efficacy. Do not allow irrigation water to flow from an infested field to other fields without impounding. Prevent animal grazing and movement from infested to uninfested fields. Sanitation: Remove or compost crop residues after harvest, let them dry out before destruction. Do crop rotation to non-host or nematode-suppressing crops like pyrethrum flower, common vetch, rapeseed, Chrysanthemum, velvet bean, partridge pea, castor bean, or sesame.	
Blights and Wilts: Sclerotial blight (*Sclerotium rolfsii*)	Sclerotium fungal infection ceaves turn to turn bronze then wilt. Circular spots develop on storage roots shortly before harvest. Lesions have sharply defined and circular margins. This fungusis soil borne. When	Use tolerant and resistant varieties, if available. Use disease-free planting stocks. Avoid fields with a history	No treatment threshold. neem seed extract azoxystrobin

Table 9. Sweet potato			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Fusarium wilt (*Fusarium oxysporum f. sp. Batatas*) (Flétrissement fusarien)	the weather is humid, a coarse white mycelium of the fungus may grow out on the soil surface around the base of the plants and up the lower part of the stems. Later, small sclerotia develop on the mycelia; these structures survive for years in the soil. Sclerotial blight is especially severe when there are ‘seed’ roots in the bed that are rotting because of some other disease, when there is dead leaf material on the surface, and when the plants are under stress from extremes of temperature or moisture. Fusarium, a soil-borne pathogen that infect seedlings, leads to red-brown lesions on stems and roots, causing them to wilt and die. Leaves turn yellow then fall off. Sometimes vines turn tan/light brown and stems crack.	of wilt. Do crop rotations. Ensure good drainage of soil. Use nitrate nitrogen rather than ammoniacal nitrogen. To reduce infection near transplanting time, hold transplants for 24 hours at 29°C to promote suberisation of the injured surface. Plant more than one transplant per hill to make up for those infected.	(Azox, Ortiva 250 SC, Ortiva Top) tébuconazole + trifloxystrobin (Nativo 300 SC)
Scab (*Elsinoë batatas*) (Maladie de la gale de la patate douce)	Leaves twist and deform, with scabby patches on the undersides. Stems show red-brown sunken lesions. A major constraint that limits production in the Sahel.	Use resistant varieties. Remove and destroy infected crop residues. Leave fields fallow. Rotate with other crops.	No treatment threshold. neem seed extract azoxystrobin (Azox, Ortiva 250 SC, Ortiva Top)

Table 9. Sweet potato			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Sweet potato virus disease complex: Sweet potato feathery mottle potyvirus (SPFMV), transmitted by aphids (mainly *A. gossypii*) in a non-persistent manner and Sweet potato chlorotic stunt crinivirus (SPCSV), transmitted in a semi-persistent manner by the whitefly *Bemisia tabaci* (Complexe viral de la patate douce)	This complex of viruses cause severe stunting of plants, the production of small distorted leaves, excessive branching, yellowing of vines and dark, brown to blackish corky spots in the roots.	Use resistant variety, Use disease free planting material. Practice proper field sanitation: remove and destroy crop residues.	No treatment threshold. To control aphids, whiteflies: Use seed piece treatment with imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract garlic extract chili extract acétamipride (Titan 25 EC)
Invertebrate Storage Pests	See pest descriptions above, under cowpea	See grain storage best practices above, under cowpea	See grain treatment above, under cowpea

Table 9. Sweet potato			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Bruchid Grain Weevils and Borers See pest species above, under cowpea			
Vertebrate Storage Pests Rodents: Rats, Mice Birds: Sparrows	See vertebrate storage pests above, under cowpea	See vertebrate storage pests above, under cowpea	See vertebrate storage pests above, under cowpea

Livestock/Fowl (REGIS-AG, protein, cash generation)

Goats/Sheep (Small ruminants)

Goats, *Capra hircus*, were first domesticated in western Asia, Turkey and Iran. Sheep, *Ovis aries*, were domesticated in Mesopotamia, Iraq and Iran. These were introduced to Africa by regional traders prior to European invasion, and are reasonably well adapted to local conditions, but not yet all the pests and diseases. They are a very portable protein source (both live and slaughtered) and are kept in West Africa by both sedentary farmers such as the Hausa, Kanuri, and Songhai, as well as the more northern Fulani and Tuareg, who are principally nomadic and semi-nomadic pastoralists. Goats and sheep are tended moslty by women and children.

Agro-pastoral farmers keep livestock as insurance against the natural and economic risks; they can be eaten or sold to pay depts or buy other goods. As the area of cultivated land increases among sedentary farmers, it competes with livestock keeping among pastoralists as well as more sedentary farmers. Although livestock is kept primarily for milk and meat, they are also used for hides, skins and leather, particularly from goats. Goat milk compares favorably in nutritive value with cow's milk. Sheep were first used for mutton, skins, milk and wool.

In Africa as in the Mideast, goats are typically run in flocks with sheep. This maximizes the production per acre, as goats and sheep prefer different food plants, with different eating habits. Goats thrive on grazing grasses, browsing, or scavenging, and can stand on their hind legs to eat leaves from shrubs and bushes. Sheep eat mostly grasses, but will also browse on low shrubs.

Table 10. Goats/Sheep (Small ruminants)

Primary Pests and Diseases	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Savannah and Riverine Tsetse flies (*Glossina spp.*) can transmit trypanosomes, *Trypanosoma brucei, T. vivax*, that lead to Trypanosomiasis/Nagana (Tsetse)	Tsetse flies bite goats and sheep, transmitting the trypanosome organism, which causes sleeping sickness.	Vaccinate against these diseases.	No treatment threshold. No insecticides are recommended
Hard livestock ticks (*Amblyomma variegatum*, *Rhipicephalus (=Boophilus) microplus*) can transmit Babesiosis and Anaplasmosis protozoal parasites, and Heartwater, *Ehrlichia ruminantium* rickesttsial disease (Tiques les bétail)	Ticks carry and transmit numerous diseases to livestock in West Africa. These include protozoans and rickettsia, which cause Babesiosis, Anaplasmosis, and Heartwater. These diseases lead to fever, loss of appetite, loss of weight, and if not treated, death.	Use tick resistant goat breeds. Vaccinate against these diseases. Use clean syringes if blood entry or transfer occurs. Check animals routinely for ticks and remove ticks by hand. Brush removal and mowing the	No treatment threshold. No acaricides are recommended

Table 10. Goats/Sheep (Small ruminants)			
Primary Pests and Diseases	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		vegetation next to wooded areas. Rotate livestock away from the pastures that are heavily infested with ticks. Sanitation: Where animals are concentrated in night corrals, clean up and remove all weeds and animal waste.	
Mange mites (*Demodex spp.; Sarcoptes spp.*) (Acariens des petits rumiants)	Tiny, microscopic mange mites feed on skin and hair, leaving patches of irritated skin. They are highly contagious. Extreme cases of mites can lead to death.	Don't over-crowd animals. Provide animals with sufficient space, so they are not in close contact with each other. Use indigenous knowledge and saltpan dips and washes to reduce mites. Use indigenous plant extracts to reduce mites.	No treatment threshold. No miticide is recommended

Poultry

Modern chickens, *Gallus domesticus*, were originally domesticated in Thailand from a red jungle fowl. From there, they spread rapidly around the world adn into Africa, prior to invasion by Europeans. Poultry production plays a prominent role in the everyday meat supply for Nigeriens and Burkinabe. Family poultry are important as provider of eggs and meat. It is generally assumed that family poultry production systems are economically efficient because, although the output from the individual bird is low, the inputs are usually lower. Output and technical efficiency of the family poultry production can be increased using more feed, capital, medicine, vaccines, and adoption of more innovations.

Table 11. Poultry

Primary Pests and Diseases	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Pigeon and fowl ticks (*Argas reflexus*, *Argas persicus*) (Tique)	Fowl ticks are small, 5-9mm, external pests of poultry. Both ticks are dark red-brown, turning blue when fully fed. The females are larger than the males. The outer surface of the tick is irregular and creased appearance. These ticks breed in cracks in poultry sheds. They are active at night, feeding on the stock. The female can produce large numbers of eggs. These eggs quickly hatch and the larvae attach to a host, where they feed. They draw several large blood meals, and then leave the host, returning to cracks in the poultry sheds. The larvae then undergo three further transformations through the nymphal stages, before becoming an adult. The complete life cycle is completed in about a month.	Prophylaxis: Manually clean equipment, houses, roosts, nests, and yards. Sanitation: Remove and burn old litter.	No treatment threshold. Acaricides are not recommended

Table 11. Poultry			
Primary Pests and Diseases	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Chicken mites (*Dermanyssus gallinae*) (Acariens de poulet)	Very tiny, 1mm, chicken mites hide and lay eggs in cracks, crevices, nests and barnyard litter when they are not feeding. They are external night feeders, with piercing-sucking mouthparts. Mites have one larval and two nymphal stages. Feeding by these mites reduces egg-laying by chickens.	Manually clean equipment, houses, roosts, nests, and yards. Heat can be applied as a control.	No treatment threshold. Miticides are not recommended.
Poultry lice: body louse (*Menacanthus stramineus*); shaft louse of poultry (*Menopon gallinae*); head louse (*Cuclotogaster heterographus*); wing louse (*Lipeurus caponis*); feather louse (*Goniodes gigas*) (Pou)	Lice are small, 1-3mm, transparent wingless ectoparasites that bother chickens, causing itching, rashes, weight loss, open wounds that are scratched, and lower egg production.	Keep wild birds away from poultry. Disinfect all equipment regularly.	No treatment threshold. Pesticides are not recommended.

Garden Vegetables (REGIS-ER)

Amaranthus leaves

Amaranth, a complex of species, *Amaranthus cruentus*, *A. hypochondriacus*, *A. caudatus*, was domesticated in Meso-America, primarily Mexico, and is grown primarily for edible leaves, which are cooked like spinach, and served as a side dish to meats and carbohydrates. The seeds are highly nutritional but rarely eaten in West Africa.

Table 12. Amaranthus leaves			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Beetworm Moth (*Spoladea* *recurvalis*)	Larvae of this moth feed on and defoliate Amaranth leaves. The moth is chocolate brown with white-striped wings. They feed on the underside of the leaves protected by a slight web. Eggs are flat and elliptical, deposited singly or in small groups. The larvae are green and resemble the ribs of the leaf. Larvae are about 19 mm long. The brown pupa is formed within a slight cocoon in a folded and tied piece of leaf. The pupal period lasts about 12 days.	Remove weeds in and around the field. Move planting date ahead to escape moth emergence.	No treatment threshold. BT (Batik WG, Bio K 16) spinosad (Laser 480 EC)

Cabbage/Lettuce

Cabbage, *Brassica oleracea*, is a leafy green, white or purple biennial plant, grown as an annual vegetable crop for its dense-leaved heads. The leaves contain some carbohydraes, proteins and various essential elements. Smooth-leafed firm-headed green cabbages are the most common, with smooth-leafed red and crinkle-leafed savoy cabbages of both colors seen more rarely. Plants perform best when grown in well-drained soil in a location that receives full sun.

Lettuce, *Lactuca sativa*, is an annual plant of the aster or sunflower family. It is most often grown as a leaf vegetable, but sometimes for its stem and seeds. Lettuce was first cultivated by the ancient Egyptians who turned it from a weed, whose seeds were used to produce oil, into a plant grown for its leaves. Lettuce is cultivated for its succulent leaves that are used in salads. Lettuce grows best in full sun in loose, nitrogen-rich soils, rare in West Africa.

Table 13. Cabbage/Lettuce			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Diamondback moth (*Plutella xylostella)* (Fausse-teigne des crucifères)	The larvae of this tiny, 3-4mm, moth feed on leaves of cole crops, including cabbage. Populations can increase rapidly in warm conditions. Larvae are slender and yellow green in color and chew holes in leaves, growing points, stems, the inflorescence and flowers, from seedling to harvest. Larvae make a silk cocoon to pupate in. Newly hatched caterpillars feed as leaf miners inside the leaf tissue leaving the upper leaf surface intact. Larvae and pupae are found on damaged leaves where as older larvae are often found around the growing bud of young plants. A major constraint that limits production in the Sahel.	Cover seedbed. Intercrop with tomato. Synchronous planting in each community between adjacent fields. Place seedling beds away from production fields. Remove and destroy or plow down crop residues. Practice crop rotation, especially in semi-arid environments, 6 weeks or more where no Brassica crops are grown by all neighbors in a locality, and follow crop rotation simultaneously. Conserve and encourage natural enemies.	Treat if 10% of infested plants in the seedbed, 30% from transplanting to cupping stage, 20% from cupping to early heading, and 10% at early heading to mature head stages. Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) BT (Batik WG, Bio K 16) neem seed extract spinosad (Laser 480 EC) chilli extract garlic extract

Table 13. Cabbage/Lettuce			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			acétamipride (Titan 25 EC)
Cabbage webworm *(Hellula undalis)* (Noctuelles)	Cabbage webworm caterpillars are creamy white with light pinkish brown stripes along the body and have a black head. They measure 15 mm when fully grown. Duration of larval development varies between 6 to 18 days, depending on temperature and on the host crops. Thus, on cabbage larval development is completed in 16 to 19 days, but on cauliflower it may require only 11 to 13 days. A major constraint that limits production in the Sahel.	Cover seedbed. Crop rotation. Use clean planting materials. Transplant only healthy, and vigorous insect-free seedlings. Uproot and burn cabbage and kale stalks after harvest.	Check 25 random plants for damage, and treat if find more than 9 small- to medium-sized larvae per plant. [10] Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals)

[10] The University of Hawaii suggests a somewhat lower threshold of 15-25% of plants infested (http://www.extento.hawaii.edu/kbase/crop/type/hellula.htm), while according to the University of Georgia “no greater than 0.3 larvae per plant should be tolerated” (http://www.caes.uga.edu/content/dam/caes-website/departments/entomology/documents/IPMVegetables/webworm.pdf)

Table 13. Cabbage/Lettuce			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			neem seed extract spinosad (Laser 480 EC) BT (Batik WG, Bio K 16)
Cabbage looper (*Trichoplusia ni*) (Noctuelles)	Cabbage looper caterpillars are green, usually with a narrow white stripe along each side and several narrow lines down the back. They can be distinguished from most other common caterpillars in cole crops by their distinctive looping behavior in which they arch the middle portion of their body to bring the prolegs or hind legs forward to meet the front legs. Although seedlings are occasionally damaged, most injury occurs after heading.	Use clean planting materials. Cover seedbed. Crop rotation. Transplant only healthy, and vigorous insect-free seedlings. Uproot and burn cabbage and kale stalks after harvest.	Check 25 random plants for damage and treat if find more than 9 small- to medium-sized larvae per plant, which is applicable before heading or right at cabbage formation. Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract garlic extract

Table 13. Cabbage/Lettuce			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			spinosad (Laser 480 EC) BT (Batik WG, Bio K 16)
Black Cutworm (*Agrotis ipsilon*) (Vers gris)	Medium, 3 cm, dark brown-black larvae of 2 cm brown moths. Eggs are cream-white colored with ribs, laid in massed rows on weed leaves. Larvae hide under debris and in the soil during the day, feeding voraciously at night, often cutting the plant off, to fell it and feed on it at the soil level. A major constraint that limits production in the Sahel.	Deep tillage. Planting time should be adjusteded to suit the reduction of investation. Remove weeds from border areas. Destroy weeds 10-14 days before planting the crop. Delay transplanting slightly until the stems are too wide for the cutworm to encircle and/or too hard for it to cut. Flood the field for a few days before sowing or transplanting.	Treat with soil drench if 10% of young plants cut or damaged. Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract spinosad (Laser 480 EC) chilli extract garlic extract diméthoate (Methoate 40 EC)

Table 13. Cabbage/Lettuce			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			BT (Batik WG, Bio K 16)
Cabbage head caterpillar/Larger cabbage webworm (*Crocidolomia binotalis*)	Green larvae of light beige to cream colored moths, 11-14mm long. Eggs are flat and laid in a shingling pattern masses. Larvae produce webbing with frass to protect themselves. They feed on wild and cultivated crucifer plants. While they can survive on any part of these plants, they prefer growing centers, blossoms and pods. One larva can destroy an entire head.	Hand-pick and destroy larvae and egg masses. Plant cabbage during the rainy season. Plant mustards near the field to trap larvae. During the first 40 days after transplanting, monitor the field and kill groups of young larvae by hand or spot-spray with Bt. This method is time efficient while densities remail below 15%. If the percentage of plants infested exceeds 15%, it becomes more effective to spary the entire field. After the first 40 days	Check 25 random plants for damage, and treat if find more than 9 small- to medium-sized larvae per plant. Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract spinosad (Laser 480 EC) chilli extract garlic extract diméthoate (Methoate 40 EC)

Table 13. Cabbage/Lettuce			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		from transplant, monitoring is no longer sufficiently effective. Cabbage must be sprayed routinely twice each week.[11]	spinosad (Laser 480 EC) BT (Batik WG, Bio K 16)
Cabbage aphid (*Brevicoryne brassicae)* and false aphid *(Lipaphis erysimi)* (Puceron du chou)	Apid feeding with lead to leaves yellowing, wilting, drying, and rolling. Large colonies can stunt or kill small plants. Malformed flowers and fruits when aphis feed on flower buds. Honeydew accumulates on leaves, blocking light and photosynthesis.	Put up insect-proof nets to protect nursery. Destroy crop remnants immediately after harvest. Remove or control alternate hosts, including mustards and related weeds, around field borders. Be sure transplants are clean before taking them to field.	Treat as soon as 1 to 2% of plants are infested with one or more aphids. Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals)

[11] http://web.entomology.cornell.edu/shelton/veg-insects-global/english/croci.html

Table 13. Cabbage/Lettuce			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			neem seed extract garlic extract chili extract
Chinch bug (*Oxycarenus hyalinipennis*)	Chinch bugs are small, 4-6 mm, blackish with transparent wings. They attack open or damaged pods mainly at the end of the growing season. Nymphs and adults suck from immature seeds, preventing them from ripening. Groups of bugs are usually found between flower buds, flowers and pods. These bugs are minor pests of okra and usually no control measures are needed.	Removal of weed hosts near fields. Sanitation: Remove plants and all its debris as soon as harvesting is over. Destroy wild alternate hosts.	No reasonable treatment threshold. Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract
Leaf miner fly (*Liriomyza species)* (Mouche mineuse des feuilles)	Leaf miners attack a wide variety of vegetable crops, particularly in the seedling stage. Adults are tiny black flies with a bright yellow spot on their thorax. Females puncture leaves to feed on plant sap and lay eggs within the leaf tissues. After 2 to 4 days, the eggs hatch and larvae feed between the upper and	Use yellow and green sticky traps to monitor and reduce populations. Use microtunnel covers to exclude leaf miners.	Check young seedlings for mines on cotyledons and the first true leaves. Treat if leafminer numbers build to high levels when seedlings have four to five leaves, with

Table 13. Cabbage/Lettuce			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	lower surface of leaves, as they move in their tunnels. Larvae emerge from the leaf mines and pupate on the leaf surface or, more commonly, drop from the plants to land in cracks in the soil. Mines appear as white marks on the leaf surface. Many generations may occur each year, and the entire life cycle can be completed in less than 3 weeks when the weather is warm. Leaf miners can reduce the plant's photosynthetic capacity, render edible leaf portions unmarketable, and provide an entrance for pathogenic organisms.	Conserve natural enemies. Parasitic wasps normally control leaf miners, if not killed by pesticide overuse. Rotate with non-host crops and plan the arrangement of fields so that old infested fields do not provide a reservoir of infestation for subsequent crops. Destroy leaf miner pupae in the soil by plowing and tilling, by solarization, and, on heavy soils, by flood irrigation.	more than an average of one mine per leaf. Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract garlic extract spinosad (Laser 480 EC) acétamipride (Titan 25 EC)
Cabbage cyst nematode (*Heterodera cruciferae*) (Nématode à kyste)	Cyst nematodes occur frequently in cole crop-growing regions and can severely damage the crop on any soil type. White, pinhead size, lemon-shaped females and brown cysts can be seen on the root surface upon careful observation.	Weed management. Crop rotation (more effective for cyst nematodes) and intercropping.	No reasonable treatment threshold.

Table 13. Cabbage/Lettuce			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	Cyst nematodes, however, do not induce gall formation on the roots. Cyst nematodes produce stunted plants, yellow leaves and reduction in head size.	Plant trap-plant like groundnut before crop. Mix cropping or cover cropping with non-host crops. Field solarization (heat treatment). Flood the plot. Use manure in nursery. Avoid growing on an infected plot. Dig up and let dry any attacked plants. Thoroughly clean all equipment with water. Do not allow irrigation water to flow from an infested field to other fields without impounding. Prevent animal grazing and movement from	fluopyram (Velum Prime 400 SC)

Table 13. Cabbage/Lettuce			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		infested to un-infested fields. Plow under infested plants after harvest. Reduce stress on plants by proper fertilization and irrigation.	
Root knot nematode (*Meloidogyne spp.*) (Nématode à galles)	Microscopic nematodes feed within plant root zones on newly developed roots. Root-knot nematodes enter and cause galls of up to 3 cm in diameter to appear on roots as quickly as a month after planting. Nematode feeding interferes with the flow of water and nutrients to the plant. Infected plants are prone to wilt in hot weather, and respond poorly to fertilizer; young plants may experience reduced vigor, slow growth, and stunting.	Do weed management Crop rotation Do intercropping. Intercropping with non-host crops. Field solarization. Flood the plot. Clean all equipment with water. Do not allow irrigation water to flow from an infested field to other fields. Prevent animal grazing and movement from	No reasonable treatment threshold. fluopyram (Velum Prime 400 SC)

Table 13. Cabbage/Lettuce			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		infested to un-infested fields. Plow under infested plants after harvest. Reduce stress on plants by proper fertilization and irrigation.	
Damping off fungi (*Phytophthora spp., Pythium spp., and Rhizoctonia spp*.) (Fonte des semis)	Soil-borne pathogens that infect seedlings, leading to red-brown lesions on stems and roots, causing them to wilt and die. A major constraint that limits production in the Sahel.	Crop rotation. Avoid wet soils. Favor good drainage and good soil aeration. Use treated seeds. Water only when soil is dry.	No treatment threshold. Use seed treated with thirame (Caiman Rouge P, Calthio Mix 485 WS, Insector T, Momtaz 45 WS--seed treatments only by professionals) méfenoxam and/or difenoconazole (Ortiva Top, Apron Star 42 WS) neem seed extract

Table 13. Cabbage/Lettuce			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP)
Downy mildew (*Peronospora parasitica*) (Mildiou)	Leaves develop yellow patches that then turn tan to light brown. Then they die from the tips downward.	Use resistant varieities Do not over irrigate, and do so in the morning. Remove and destroy crop residues after harvesting. Maintain good weed control.	No treatment threshold. neem seed extract mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP)
Black rot (*Xanthomonas campestris pv. campestris*) (Pourriture noire)	Black rot bacterium can over-season on infected cabbage seeds, and in weeds belonging to the Brassica family, or in infected plant material in the soil. It can persist in plant residue for 1-2 years or if the plant debris remains intact, and can be carried on or in the seed. Diseased plants may rot quickly before or after harvest because of secondary infection from bacterial soft-rot. Black rot development is favored by warm,	Use resistant varieties Use certified seed. Sterilize seed in 50-degree C water. Use deep plowing. Do crop rotations using non-hosts, and with crucifer crop no more often	No treatment threshold. No bactericides are recommended

Table 13. Cabbage/Lettuce			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	humid conditions. Splashing water from rain or sprinklers spreads the pathogen from plant to plant. Angular or V-shaped chlorotic lesions appear along the leaf edges. Severely infected leaves may wither and drop off. With systemic infection, vascular tissues in petioles and main stems can also turn black.	than every 2 years in any infected field. Remove weed and volunteer crucifers.	
Alternaria leaf spot (*Alternaria brassicae*) (Alternariose)	Round tan spots with yellow border on leaves (0.1-0.3 mm in diameter). Elongated spots with grey center on stems. Alternaria does not survive in soil, but is carried over in crucifer seed, on weed or volunteer hosts, or on undecomposed crop residue and is favored by moist conditions. Spores are spread by winds and splashing water. If conditions are favorable, dark green spores of the pathogen will grow on the leaf spots, forming concentric rings. Old leafspots become papery in texture and may tear. When the dry tissue falls out, a shothole effect results.	Use resistant varieties Use clean seed. Do crop rotation of 3-4 years if there is an infestation. Remove and destroy all crop residues. Avoid watering foliage at the end of day or at night. Limit crop stress, such as poor fertility, drought, insect damage, and heavy fruit.	No treatment threshold. mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP) tébuconazole + trifloxystrobin (Nativo 300 SC) neem seed extract garlic extract

Carrots

Carrots, *Daucus carota subsp. sativus*, native to Asia, are one of the most common vegetable root crop grown in West Africa and an important source of Vitamin A in human diets. Carrot roots are rich in beta-carotene, as well as carbohydrate and moderate amounts of protein. They are consumed raw or cooked, alone or in combination with other vegetables (for example, peas), as an ingredient of soups and sauces. Young leaves are sometimes eaten raw or used as fodder. Carrots are grown as cash crops in areas with plentiful irrigation water.

Table 14. Carrots			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Aphids: Green peach (*Myzus persicae*) cotton (*Aphis gossypii*) (Pucerons)	Aphids attack terminal leaves, flower heads, and stems. Infested plants develop yellow foliage, may become dwarfed and malformed, and lose vigor. Symtoms include stunted, wilted and discolored plants, leaves curl downward and pucker. Heavily infested plants turn brown and die from the top down. Aphids produce sticky honeydew on which grows black sooty mold, blocking sunlight and photosynthesis.	Do early planting. Use silver mulches. Use resistant varieties. Use regular monitoring with yellow sticky traps. Many natural enemies and pathogens control these aphids under low insecticide use. Sanitation: Field disking and destruction of crop residues are important for control of aphid pests of leafy vegetables to reduce their migration into nearby crops	No treatment threshold. Use seed treated with imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) or thiamethoxam (Apron Star 42 WS) neem seed extract garlic extract

Table 14. Carrots			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			chili extract
Damping off, Root dieback (*Alternaria spp., Fusarium spp., Pythium spp., Rhizoctonia solani*) (Fonte des semis)	Soil-borne pathogens that infect seedlings, leading to red-brown lesions on stems and roots, causing them to wilt and die.	Use resistant varieties. Disinfect seeds. Use a crop rotation of 3-4 years. Avoid watering the foliage at the end of the day or at night. Do not plant new fields near existing fields with blight symptoms. If possible, use furrow irrigation. Remove and destroy crop debris.	No treatment threshold. Use seed treated with thirame (Caiman Rouge P, Calthio Mix 485 WS, Insector T, Momtaz 45 WS--seed treatments only by professionals) neem seed extract garlic extract mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP) tébuconazole +

Table 14. Carrots			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			trifloxystrobin (Nativo 300 SC)
Powdery mildew (*Sphaerotheca fuliginea, Erysiphe cichoracearum*) (Oïdium ou Blanc)	Powdery mildew fungi produce white powdery growth consisting of large numbers of fungal spores, which are spread by wind. The disease can spread very rapidly. The pathogens generally overseason on weeds. Powdery mildews are severe in warm, dry climates because the fungus does not need the presence of water on the leaf surface for infection to occur. However, the relative humidity of the air needs to be high for spore germination. Therefore, the disease is common in crowded plantings where air circulation is poor and in damp, shaded areas. Young, succulent growth usually is more susceptible than older plant tissues.	Use resistant varieties Remove weeds. Avoid late-season applications of nitrogen fertilizer. Avoid overhead watering. Remove and destroy all infected plant parts.	No treatment threshold. neem seed extract azoxystrobin (Azox, Ortiva 250 SC, Ortiva Top) tébuconazole + trifloxystrobin (Nativo 300 SC)
Alternaria leaf blight (*Alternaria dauci*) (Alternariose)	Alternaria leaf blight pathogen survives on and is spread on carrot seed, debris and on volunteer carrots. However, once the crop residue decomposes, the fungus dies. Spores are dispersed in air and splashing water. Leaves weakened by blight may break off when gripped by mechanical harvesters, resulting in the roots being left in the ground. Lesions	Use resistant varieties. Disinfect seeds. Use a crop rotation of 3-4 years. Avoid watering the foliage at the end of the day or at night.	No treatment threshold. Treat the seed with: thirame (Caiman Rouge P, Calthio Mix 485 WS,

Table 14. Carrots			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	that develop on petioles may kill entire leaves. The pathogen also causes damping-off of carrot seedlings. The disease is favored by rainy weather and/or overhead irrigation. The optimum temperature for growth and infection is 28°C with some infection occurring at temperatures as low as 14°C and as high as 35°C.	Do not plant new fields near existing fields with blight symptoms. If possible, use furrow irrigation. Remove and destroy crop debris.	Insector T, Momtaz 45 WS--seed treatments only by professionals) garlic extract mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP) tébuconazole + trifloxystrobin (Nativo 300 SC)

Corchorus plant leaves

Corchorus plants, *Corchorus olitorius*, are native to most tropical and subtropical parts of the world, and are used as food and fiber in the Middle East, as well as North and West Africa. Leaves are cooked and consumed like a local 'spinach' as a side to meats and starch-based dishes in Sahelien countries.

- No serious pests or diseases

Cucurbits: cucumber/pumpkin/squash/watermelon/cantaloupe

Pumpkins and squashes, *Cucurbita pepo*, are native to North America, distinguishing them is often difficult. They were introduced by Europeans to Africa, where they were not adapted to local conditions, pests and diseases. Pumpkins have long-running, bristled stems, large deeply-lobed leaves often containing white blotches and yellow or orange flowers separated into male and female types on the same plant. The fruit is variable in shape and color but is often white, cream or green, containing about 70% flesh and several large white seeds. Fruits, leaves and flowers of cucurbits are used as vegetables, and their seeds are consumed roasted as a snack food. Pumpkin and squash are boiled and form a part of the diet of people of the Sahel cooked in a pot with peanut sauce and greens and served with rice and meat. Pumpkins and squashes are planted in home gardens or mixed with field crops such as maize; and are sometimes monocropped for commercial production.

Watermelon, *Citrullus lanatus*, is indigenous to the dry plains of tropical and subtropical southern Africa, perhaps in the general area of present day Namibia/Botswana. It is one of the most widely cultivated crops in the world and its global consumption is greater than that of any other cucurbit. Orange and green fruited melons, *Cucumis melo*, are indigenous to Persia and parts of Eastern Africa, where they are adapted to semi-arid climates.

Table 15. Cucurbits: cucumber/pumpkin/squash/watermelon/cantaloupe

Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Cotton/melon aphid *Aphis gossypii* (Puceron du cotton/melon)	The melon aphid, also called cotton aphid, is a small aphid that ranges in color from yellowish green to greenish black. Both winged and wingless forms are produced. The winged individuals are slender and are not as robust as the wingless form. Mature aphids are 1.5 mm in length. The melon aphid can be distinguished from other aphids by the color of its cornicles at the tip of the abdomen, which are always black. Unlike other aphids, melon aphid populations do not diminish with high	Ensure that the crop is well watered and well-nourished particularly with nitrogen fertilizer. Conserve natural enemies. Use yellow sticky cards to monitor the movement of aphids and whiteflies before planting seed or transplants. Start checking traps after transplanting or when seedlings emerge. When aphids are	No treatment threshold. Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done

Table 15. Cucurbits: cucumber/pumpkin/squash/watermelon/cantaloupe			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	temperatures. The melon aphid develops in colonies and prefers the underside of leaves. Initially they are present on tender parts of the plant (young shoots and leaves), but as their number increases they can cover the entire plant. As the colony grows, winged aphids are produced which fly away looking for new plants to start a new colony. A major constraint that limits production in the Sahel.	observed on traps, begin monitoring crop foliage.	only by professionals) neem seed extract garlic extract spinosad (Laser 480 EC) acétamipride (Titan 25 EC)
Fruit flies (*Bactrocera cucurbitae, Dacus bivittatus, D. ciliatus*) (Mouche des fruits)	Fruit flies cause direct damage by puncturing the fruit skin to lay eggs. During egg laying, bacteria from the intestinal flora of the fly are introduced into the fruit, which cause rotting of the tissues surrounding the egg. When the eggs hatch, the maggots feed on the fruit flesh making galleries. These wounds provide entry for pathogens and increase the fruit decay, making fruits unsuitable for human consumption. Fruits can fall to the ground as, or	Use shallow powing. Use yellow sticky or pheromone traps for monitoring. Twice a week, for the entire season remove fruits with dimples oozing clear sap. Bury infested fruits at least 50 cm deep. Practice early harvest.	No treatment threshold. Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done

Table 15. Cucurbits: cucumber/pumpkin/squash/watermelon/cantaloupe			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	just before the maggots pupate. Fruit flies pose quarantine restrictions for export of the fruit. A major constraint that limits production in the Sahel.	Bagging works well with watermelon. Set out fruit fly traps baited with curelure.	only by professionals) neem seed extract garlic extract spinosad (Laser 480 EC) acétamipride (Titan 25 EC)
Whitefly (*Bemisia tabaci*) (Mouche blanche)	Whiteflies are tiny, 2 mm, white, insects with piercing-sucking mouthparts. They occur in groups on the undersides of leaves, laying eggs, which develop into nymphs that also suck plant sap from the leaves. Outbreaks, leading to leaf-wilting and death under drought stress, often occurs when the natural biological control is disrupted by over-use of pesticides.	Do intercropping and interplanting crops Use yellow sticky traps for monitoring. After the last harvest, destroy all crop residues. Ensure good growing conditions for the crop. Avoid application of high doses of nitrogen fertilizer.	No treatment threshold. Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals)

Table 15. Cucurbits: cucumber/pumpkin/squash/watermelon/cantaloupe			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			neem seed extract garlic extract spinosad (Laser 480 EC) acétamipride (Titan 25 EC)
Pumpkin beetle (*Aulacophora africana*) (scarabée potiron)	Adult beetles feed on and defoliate the plant and feed on the skin of fruit. Flowers are destroyed and feeding on the skin of fruit causes blemishes.	Handpick adults. Remove and bury crop residues deeply. Put wood ash at the bottom of seedlings. Practice crop rotation. Rotate: Do not plant any members of the cucurbit family in the same place year to year, and plant with a cover crop, such as red clover. Provide conditions for healthy plant growth (manures and, or commercial fertilizers, and adequate water).	Monitor 20 plants at the seedling stage weekly, and treat if 1 adult per plant. After one month, the threshold is 3 adults per plant. Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done

Table 15. Cucurbits: cucumber/pumpkin/squash/watermelon/cantaloupe			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		Use straw mulches.	only by professionals) neem seed extract spinosad (Laser 480 EC) acétamipride (Titan 25 EC)
Spider mites (*Tetranychus spp., Mononychellus spp., Oligonychus spp.*) (Tétranyque)	Mites are tiny 8-legged acarids that feed with piercing mouthparts, in groups on leaf undersides. Spider mites usually produce webbing to protect themselves. Extensive feeding causes leaf wilt and death, and is exacerbated by warm dry weather and drought. First symptoms of spider mite feeding are usually clusters of yellow spots on the upper surface of leaves, which may also appear chlorotic and get a speckled or mottled appearance. Attacked leaves	Install windbreaks around the field. Leave a distance between the crop and the field borders. Remove and destroy heavily-infested plants, as well as crop residues after harvest. Avoid water and nutrient stress by applying mulch and incorporate organic matter into the soil.	No treatment threshold. neem seed extract garlic extract chili extract abamectine (Abalone 18 EC, Acarius 18 EC, Bomec 18 EC, Vertimec 18 EC)

Table 15. Cucurbits: cucumber/pumpkin/squash/watermelon/cantaloupe			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	turn bronze, or rusty, purple or yellow brown color, and stems turn brown. Fruits can crack.	Keep the field free of weeds.	
Leaf miner (*Liriomyza trifolii*) (Mouche mineuse des feuilles)	Leaf miners attack a wide variety of vegetable crops, particularly in the seedling stage, often grown in proximity to cole crops. Adults are tiny black flies with a bright yellow spot on their thorax. Females puncture leaves to feed on plant sap and lay eggs within the leaf tissues. After 2 to 4 days, the eggs hatch and larvae feed between the upper and lower surface of leaves, as they move in their tunnels. Larvae emerge from the leaf mines and pupate on the leaf surface or, more commonly, drop from the plants to land in cracks in the soil. Many generations may occur each year, and the entire life cycle can be completed in less than 3 weeks when the weather is warm. Leaf miners can reduce the plant's photosynthetic capacity, render edible leaf portions unmarketable, and provide an entrance for pathogenic organisms.	Use yellow and green sticky traps to monitor and reduce populations. Use microtunnel covers to exclude leaf miners. Conserve natural enemies. Parasitic wasps normally control leaf miners, if not killed by pesticide overuse. Rotate with non-host crops and plan the arrangement of fields so that old infested fields do not provide a reservoir of infestation for subsequent crops. Destroy leaf miner pupae in the soil by plowing and tilling, by solarization, and, on heavy soils, by flood irrigation.	No reasonable treatment threshold Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract garlic extract acétamipride (Titan 25 EC) spinosad (Laser 480 EC)

Table 15. Cucurbits: cucumber/pumpkin/squash/watermelon/cantaloupe			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Root knot nematode (*Meloidogyne* spp.) (Nématode à galles)	Microscopic nematodes feed within plant root zones on newly developed roots. Root-knot nematodes enter and cause galls of up to 3 cm in diameter to appear on roots as quickly as a month after planting. Nematode feeding interferes with the flow of water and nutrients to the plant. Infected plants are prone to wilt in hot weather, and respond poorly to fertilizer; young plants may experience reduced vigor, slow growth, and stunting.	Use resistant varieties. Do weed management in field. Use crop rotation, fallow, and intercropping, mixed cropping or cover cropping with non-host crops. Field solarization (a transparent polyethylene film is laid over moist soil for a 6-to-12-week period to heat). Flood the plot. Avoid growing on a known infected plot. Use 2 kilos of compost per plant to enhance soil organic matter and microbial composition. Plant Marigold (pyreuthrum flower)	No reasonable treatment threshold. fluopyram (Velum Prime 400 SC)

Table 15. Cucurbits: cucumber/pumpkin/squash/watermelon/cantaloupe			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		and plow under the soil 2 months later. Use Tithonia diversifolia as organic compost. Do "biofumigation" of the soil by growing, grinding/macerating and plowing under crucifers/mustards, and covering the soil with plastic, if available, until just before planting. Rotting crucifers produce toxic gasses that kill nematodes, and covering with plastic increases efficacy. Do not allow irrigation water to flow from an infested field to other fields without impounding. Prevent animal grazing and movement from infested to uninfested fields. Sanitation: Remove or compost crop residues	

Table 15. Cucurbits: cucumber/pumpkin/squash/watermelon/cantaloupe			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		after harvest, let them dry out before destruction. Do crop rotation to non-host or nematode-suppressing crops like pyrethrum flower, common vetch, rapeseed, Chrysanthemum, velvet bean, partridge pea, castor bean, or sesame.	
Anthracnose (*Colletotrichum lagenarium*) (Pourriture rouge)	The lifecycle of anthracnose diseases involves essentially production of spores on susceptible hosts, dispersal of spores, penetration of host tissue, initiation of an infection process within the cells, development of lesions, formation of bristly spores and dispersal. The anthracnose pathogen reaches its most serious dimension at high moisture and warm temperature. Spore germination, dispersal and infection require relative humidities near 100%. However, in drier situations disease expression can occur when latent infections are	Use resistant varieties. Use clean planting materials. Control weeds, remove and destroy or bury heavily-infected plants and fruits. Use crop rotation of 3 years without solanaceae. Avoid overhead watering. Harvest fruits as soon as ripe.	No treatment threshold Use seed treated with thirame (Caiman Rouge P, Calthio Mix 485 WS, Insector T, Momtaz 45 WS--seed treatments only by professionals) Difenoconazole (Ortiva Top, Apron Star 42 WS)

Table 15. Cucurbits: cucumber/pumpkin/squash/watermelon/cantaloupe			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	activated through aging or tissue damage. The anthracnose diseases are primarily transmitted through seed, but also through infected plant parts, insects or other forms of contact. Rain splash and moist wind will also disperse spores within crop canopy. The pathogen persists on and in seed, crop residues, and weed hosts. Anthracnose diseases attack all plant parts at any growth stage. Disease symptoms are most visible on leaves and ripe fruits. First symptoms include small and irregular yellow, brown, dark-brown or black spots. These can expand and merge. On stems, this disease can cause cankers. Infected fruit has small, 1cm, water-soaked, sunken, circular spots. The center of an older spot becomes blackish and emits gelatinous pink spore masses.	Plow under the crop residues and straw mulches.	mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP) tébuconazole + trifloxystrobin (Nativo 300 SC)
Powdery mildew (*Sphaerotheca fuliginea, Erysiphe*	Powdery mildew fungi produce white powdery growth consisting of large numbers of fungal spores, which are	Use resistant varieties.	No treatment threshold

Table 15. Cucurbits: cucumber/pumpkin/squash/watermelon/cantaloupe			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
cichoracearum) (Oïdium ou Blanc)	spread by wind. The disease can spread very rapidly. The pathogens generally overseason on weeds. Powdery mildews are severe in warm, dry climates because the fungus does not need the presence of water on the leaf surface for infection to occur. However, the relative humidity of the air needs to be high for spore germination. Therefore, the disease is common in crowded plantings where air circulation is poor and in damp, shaded areas. Young, succulent growth usually is more susceptible than older plant tissues.	Use proper plant spacing. Selectively prune overcrowded plant material. Use soil solarization. Avoid late-season applications of nitrogen fertilizer. Avoid overhead watering. Remove and destroy weeds, infected plants, and plant residues.	neem seed extract azoxystrobin (Azox, Ortiva 250 SC, Ortiva Top) tébuconazole + trifloxystrobin (Nativo 300 SC)
Downy mildew (Pseudoperonospora cubensis) (Mildiou)	Symtpoms include pale green or yellow angular spots that become covered with white-purple growth, and mottling. Spots coalesce and the leaf turns brown. Young leaves and cotyledons may drop off when yellow.	Use resistant varieties. Use proper plant spacing. Selectively prune overcrowded plant material. Use only certified disease-free seeds and planting material.	No treatment threshold mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP)

Table 15. Cucurbits: cucumber/pumpkin/squash/watermelon/cantaloupe			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		Practice crop rotation with non-cucurbits. Ensure that soil is well drained. Practice early planting. Remove weed hosts found in between crops. Remove and destroy crop residues after harvest.	
Viruses Cucumber mosaic virus, CBMV, Watermelon mosaic virus, WMV, Zucchini yellow mosaic virus, ZYMV. All viruses transmitted by aphids (*Aphis gossypii, Myzus persicae*) in a non-persitent fashion	Leaves turn mosaic with light to dark green patches, with some fraying. Flowers can fall and fruits become bumpy or wrinkled, sometimes with yellow to black rings. Aphids can acquire CBMV from an infected plant in 10 to 30 seconds and transmit the virus after feeding for as few as 9 seconds. A major constraint that limits production in the Sahel.	Use resistant varieties. Use only certified disease-free seeds and planting material. Rogue out infected plants. Weed the plot. Disinfect hands and tools with 70% alcohol after contact with infected plants.	See aphid control, above

Table 15. Cucurbits: cucumber/pumpkin/squash/watermelon/cantaloupe			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Papaya ring spot virus, PRSV, transmitted by mechanical activities like pruning and by numerous aphid species such as *Myzus persicae* (Virus des taches en anneau du papayer)	Leaves yellow and mottled in a mosaic pattern with lighter veins, and round spots on leaves. Sometimes stunts the plant. On fruits, dark green ring spots form, and that can turn brown or grey at maturity, leading to deformities.	Rogue out and destroy infected plants.	See aphid control, above
Damping off fungi (*Phytophthora ssp., Fusarium oxysporum* f. sp *cepae, Pythium spp., and Rhizoctonia spp*.) (Fonte des semis)	Soil-borne pathogens that infect seedlings, leading to red-brown lesions on stems and roots, causing them to wilt and die. Surviving plants may have reduced growth and yellowing leaves. A fine white powder can be seen on the soil surface. In areas where the water table is not very deep, like the zones of the Dallol Bosso, Niger. A major constraint that limits production in the Sahel.	Use crop rotation. Avoid planting in heavy, wet soils. Favor good drainage and good soil aeration. Use treated seeds. Water only when soil is dry.	No treatment threshold Seed treatments mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP) thirame (Caiman Rouge P, Calthio Mix 485 WS, Insector T, Momtaz 45 WS--seed treatments only by professionals)

Table 15. Cucurbits: cucumber/pumpkin/squash/watermelon/cantaloupe			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			neem seed extract tébuconazole + trifloxystrobin (Nativo 300 SC)
Cercosporiosis leaf spots (especially watermelon) (*Cercospora citrullina)* (Cercosporiose) most common on watermelon, cantaloupe and cucumber	This disease usually attacks foliage, but if the environment is suitable, symptoms may also occur on petioles and stems. The fungus does not infect fruit. On watermelon, leaf spots start on young leaves as small grey or white spots with black margins. Larger leaf spots which are circular to irregularly circular develop with centers of these that are tan to light brown, becoming transparent and brittle with time. Lesions with chlorotic halos may merge and turn leaves yellow. Defoliation from the disease may reduce fruit size and quality.	Use resistant and tolerant varieties. Use clean seed. Avoid overhead watering. Water early in the morning. Crop rotation for 2-3 years with sorghum, maize, or fodder plants. Remove and destroy by burning infected leaves, crop residues and heavily infected plants.	No treatment threshold Spray fungicides late in the afternoon: mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP) tébuconazole + trifloxystrobin (Nativo 300 SC) neem seed extract

Hibiscus flowers/Bissap

Hibiscus sabdariffa probably originates from Africa, where it may have been domesticated in Sudan about 6000 years ago, first for its seed and later for leaf and calyx production. Hibiscus is suited for planting in bio-reclaimed lands. The flower calyx is dried, then boiled in water to make into a purple tea or drink, and served with honey across West Africa as Bissap.

Table 16. Hibiscus flowers/Bissap

Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Aphids (*Aphis gossypii*)	Aphids attack terminal leaves, flower heads, and stems. Infested plants develop yellow foliage, may become dwarfed and malformed, and lose vigor. Symtoms include stunted, wilted and discolored plants, leaves curl downward and pucker. Aphids produce sticky honeydew on which grows black sooty mold, blocking sunlight and photosynthesis.	Use tolerant varieties. Remove weeds from field and margins.	No treatment threshold neem seed extract garlic extract chili extract
Hibiscus Mealybug (*Maconellicoccus hirsutus*)	A small, 3mm, white waxy covered insect with piercing-sucking mouthparts. Eggs are deposited as white, cottony masses on the trunk and stems of hibiscus, giving the appearance of cotton. Feeding results in distorted, wilted, and yellowed leaves, premature leaf drop, stunted growth, and occasional death of infested plant parts or plants. Honeydew falls on leaves and fruits, resulting in the growth of sooty mold. Mealybugs are transported on the wind, on	Mealybug populations are naturally regulated by predators and parasitic fungi. Thourough cleanining of harvest equipment and fruit sacks.	No treatment threshold neem seed extract garlic extract chili extract

Table 16. Hibiscus flowers/Bissap			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	ants, bird's feet, and orchard workers.		
Spiny bollworm (*Earias insulana, E. vittella)*	The full grown dull-green caterpillars are 2 cm long, have tiny stout bristles and a series of longitudinal black spots on the body. The incidence of bollworm usually occurs during humid conditions after the rainfall. The adult female lays eggs individually on leaves, floral buds and slowers. The larvae feed on leaves and flowers. Flowers damaged and contaminated with frass are not marketable.	Conserve natural enemies which can control bollworm over time. Hand-pick and destroy larvae.	No treatment threshold BT (Batik WG, Bio K 16) neem seed extract garlic extract
Fusarium wilt (*Fusarium oxysporum f. sp. Lycopersici*)	Soil-borne pathogens that infect seedlings, leading to red-brown lesions on stems and roots, causing them to wilt and die. A major constraint that limits production in the Sahel.	Use resistant varieties. Sterilize nursery bed soil. Increase soil pH to 6.5 to 7.0 with lime or compost. Remove and destroy fallen leaves and flowers.	No treatment threshold neem seed cake applied to soil tébuconazole + trifloxystrobin (Nativo 300 SC)

Table 16. Hibiscus flowers/Bissap			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		Clean farm equipment. Avoid root damage. Do not locate seedbeds on land where Fusarium wilt is known to have occurred.	
Root/collar rot (*Phythophthora spp.*) (Pourriture de la racine/du collet)	A soil-borne disease, transported by water moving through the soil. Infects weakened plants or plants with root damage from other organisms, and causes red-brown rotting of roots and hibiscus collars at the soil level, leading to stunted and dying plants.	Grafting onto resistant root stock. Amend soil with compost. Dig drainage ditches. Avoid over-watering. Place drip irrigation spigots away from tree trunks. Remove and destroy infected plants.	No treatment threshold Apply to soil: neem seed cake mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP)

Moringa Tree leaves

The drumstick tree, *Moringa oleifera*, native to India-Pakistan-Nepal border region, is a slender, fast growing, small deciduous tree reaching 9 to 15 m in height. The leaves are exceptionally nutritious with a variety of potential uses. It has been cultivated for use as food, medicine and animal feed for centuries and has been promoted and spread by donors as another source of local 'spinach' and as a cash crop for women who pick and cook the leaves and carry them to town for sale.

Table 17. Moringa Tree leaves

Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Moringa leaf caterpillar (*Noorda blitealis)*	These larvae of a medium, 1.5-2cm moth, feed on Moringa leaves, and in large numbers, can defoliate trees. A major constraint to production in the Sahel.	Many narive parasites and predators attack and feed on these caterpillars; use care to conserve them by not over-spraying with synthetic insecticides.	No treatment threshold BT (Batik WG, Bio K 16) neem seed extract
Mites Red spider mite (*Tetranychus cinnabarinus*) Two-spotted spider mite (*Tetranychus urticae*)	Mites are tiny 8-legged acarids that feed with piercing mouthparts, in groups on leaf undersides. Spider mites usually produce webbing to protect themselves. Extensive feeding causes leaf wilt and death, and is exacerbated by warm dry weather and drought. First symptoms of spider mite feeding are usually clusters of yellow spots on the upper surface of leaves, which may	Use more resistant varieties Eliminate other host plants on or near the plantation. Maintain a clean plantation, remove weeds and heavily infested twigs and branches.	No treatment threshold neem seed extract garlic extract chili extract abamectine (Abalone 18 EC, Acarius 18 EC, Bomec 18 EC, Vertimec 18 EC)

Table 17. Moringa Tree leaves			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	also appear chlorotic and get a speckled or mottled appearance. Attacked leaves turn bronze, or rusty, purple or yellow brown color, and stems turn brown. A major constraint to production in the Sahel.		
Soil pest: Termites (*Coptotermes spp.*) (termites)	Termites are generally white to cream-colored, 3-7 mm, with red-brown heads. They live in a protected nest or mound and travel to crops through dried mud and saliva tubes in the soil and up trees, stalks and other structures. The tubes protect termites from dessication. Termites feed on tree bark, often girdling twigs, branches and smaller trees, disrupting movement of nutrients and water, killing parts or the entire tree.	Use tolerant varieties. Locate and destroy termite nests and mounds near crop fields. Use healthy uninfested cuttings and seedlings. Use an organic and non-organic fertilizer combination to favor the growth of the seedlings. Continually monitor trees for mud tubes, manually remove.	No treatment threshold No insecticides are recommended
Damping off (*Diplodia spp.*)	Soil-borne pathogens that infect seedlings, leading to red-brown lesions on stems and roots, causing them to wilt and die. This fungal disease	Use clean planting material. Plant on raised beds.	No treatment threshold

Table 17. Moringa Tree leaves			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	occurs in wet and waterlogged soils, causing severe wilting of seedlings and death of saplings.	Use soil that drains well.	mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP)

Okra/Gombo

Okra, *Abelmoschus esculentus*, originated in Ethiopia and has spread across the continent where it is extremely popular in African cooking as a thickener. It is mainly grown for its young immature pods, which are consumed as a raw vegetable, cooked, fried, or made into stew. The pods can be conserved by drying or pickling. The leaves are sometimes used as spinach or cattle feed, the fibres from the stem for cord, the plant mucilage for medical and industrial purposes, and the seeds, that contain good quality oil and protein, as a substitute for coffee.

Okra is now cultivated as an irrigated crop during the dry season, where it is often produced in mixed cropping with onion and other crops. On degraded land, okra has proved to be an important rainfed crop. Although okra is considered a robust plant, under large-scale commercial production, yield losses are very high due to the incidence of several pest and abiotic stresses.

Table 18. Okra/Gombo			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
African bollworm/Tomato Fruitworm (*Helicoverpa armigera*) (Ver de la capsule africain)	Bollworms are large caterpillars, 12-20 cm long, brown-green, with stripes on each side. They have stiff hairs on each abdominal segment that	Check for and conserve natural predators and parasites that can control large numbers of Helicoverpa larvae.	No reasonable treatment threshold

Table 18. Okra/Gombo			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	differentiate them from cutworms and armyworms. Adults are brown moths, 1.5-2 cm long. White eggs are laid in small groups on leaves. High populations inflict significant damage, particularly during droughts, if larvae consume flowers and pegs during podding. Vigorously growing plants with adequate available moisture are better able to replace damaged leaves and compensate for flower and pod damage. A major constraint to production in the Sahel.	Use insect pheromone traps near the field to monitor for presence, to know when to monitor for eggs. Two weeks before planting, remove weeds and grasses to destroy larvae and adults harboring in those weeds and grasses. Plow, disc and harrow fields at least two times before sowing seeds to expose pupae to predators. Sow seeds thinly and remove competing weeds to produce vigorous plants, which are more likely to withstand pests and diseases. Avoid planting crops successively that are hosts, like corn, cotton, sorghum, tobacco and soybean.	Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract garlic extract BT (Batik WG, Bio K 16) spinosad
Cotton aphid (*Aphis gossypii*) (Puceron du coton)	Aphids attack terminal leaves, flower heads, and stems. Infested plants	Use regular monitoring, yellow sticky traps.	Treat for aphids if high populations persist for 7 or

Table 18. Okra/Gombo			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	develop yellow foliage, may become dwarfed and malformed, and lose vigor. Symtoms include stunted, wilted and discolored plants, leaves curl downward and pucker. Heavily infested plants turn brown and die from the top down. Aphids produce sticky honeydew on which grows black sooty mold, blocking sunlight and photosynthesis. A major constraint to production in the Sahel.	Use resistant varieties. Many predators and parasitoids attack aphids, especially in orchards that are not sprayed or sprayed with less toxic materials. Remove infested culls and weedy species around field.	more days. The treatment threshold is 25% of infested seedlings, 50 aphids per plant at later growth stages. Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract garlic extract chili extract
Flea beetles (*Podagrica spp.*) (Altise)	Flea beetles are small, 2-3mm, dark brown or black, and eat out little holes, called shot-holes, in the leaves of a young crop as	Observe plants as early as possible to identify beetles to invade field.	One week after crop emergence, sample the field to note feeding damage by flea

Table 18. Okra/Gombo			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	well as on cotyledons and stems. The attacks flowers, green pods, and fruits, which leads to rotting. Eggs are laid near attacked plants in the soil. Larvae feed on the roots. Vectors of Okra mosaic virus, see below.	Avoid growing okra near cotton crops or Hibiscus. During the dry season, plough the soil down to 30 to 40 cm to expose larvae. Weed in and around the field.	beetles. If the damage occurs on more than 25% of the seedlings, treat with approved pesticides Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract
Whitefly (*Bemisia tabaci*) (Mouche blanche)	Whiteflies are tiny, 2 mm, white, insects with piercing-sucking mouthparts. They occur in groups on the undersides of leaves, laying eggs, which develop into nymphs that also suck plant sap from the leaves.	Do intercropping and interplanting crops Use yellow sticky traps for monitoring.	Monitor 20 plants weekly before fruit development, particularly at field margins. Treat if 40% of leaves average at least 3 adults.

Table 18. Okra/Gombo			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	Outbreaks, leading to leaf-wilting under drought stress, often occurs when the natural biological control is disrupted by over-use of pesticides.	After the last harvest, destroy all crop residues. Ensure good growing conditions for the crop. Avoid application of high doses of nitrogen fertilizer.	Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract garlic extract chili extract acétamipride (Titan 25 EC) spinosad (Laser 480 EC)
Leafhopper (*Empoasca lybica*) (Cicadelle)	This small, 5-7 mm, wedge-shaped insect is light green to yellow. Both adults and nymphs pierce and suck undersides of leaves feeding on phloem. Toxins passed into plants at feeding sites produce a symptom called hopper	Use resistant varieties. Control weeds, especially grasses, on field margins. Create a barrier of 10m of bare ground between crop field and	Treat as soon as damage is noted. Use seed treated with thiamethoxam

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	burn, whereby leaves yellow near the center and tips, and plant growth can be stunted, resulting in reductions in yield and grade. Damage is worse when plants are stressed, and young.	previously infested crops, which can reduce leafhopper movement. Provide adequate moisture through timely irrigation. Row covers can prevent leafhoppers from feeding on crops. Use intercropping.	(Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract garlic extract chili extract acétamipride (Titan 25 EC)
Spotted and Spiny Bollworm (*Earias vittella, E. insulana*) (Ver de la capsule tacheté; Ver de la capsule épineux)	The full grown dull-green caterpillars are 2 cm long, have tiny stout bristles and a series of longitudinal black spots on the body. The incidence of bollworm usually occurs during humid conditions after the rainfall. The adult female lays eggs individually on leaves, floral buds and slowers. The larvae feed on leaves and flowers. Flowers damaged and	Conserve natural enemies which can control bollworm over time. Hand-pick and destroy larvae.	Monitor 20 plants weekly after flowering and treat if 5% of plants are damaged. Treat caterpillars before they bore into the pods. Use seed treated with thiamethoxam

Table 18. Okra/Gombo			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	contaminated with frass are not marketable.		(Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) BT (Batik WG, Bio K 16) neem seed extract garlic extract
Blister beetle (*Mylabris spp.*) (Coléoptères/Scarabée cloque/ampoule)	Soft-shelled, 2-3 cm long beetles, usually black and yellow or red, that produce a toxic, burning fluid when disturbed, feed on flowers and pollen from a wide range of plant families. Adults are highly mobile and seek out plants in flower to feed, resulting in lower yield and often serious damage. It is difficult to control this pest with insecticides as the beetles feed on flowers that persist only for a day	Use tolerant varieties. Plant a trap crop of flowering plants on field margin, plow under.	No treatment threshold Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done

Table 18. Okra/Gombo			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	before moving to other plants.		only by professionals) neem seed extract acétamipride (Titan 25 EC)
Leaf miner (*Liriomyza trifolii*) (Mouche mineuse des feuilles)	Leaf miners attack a wide variety of vegetable crops, particularly in the seedling stage, often grown in proximity to cole crops. Adults are tiny black flies with a bright yellow spot on their thorax. Females puncture leaves to feed on plant sap and lay eggs within the leaf tissues. After 2 to 4 days, the eggs hatch and larvae feed between the upper and lower surface of leaves, as they move in their tunnels. Larvae emerge from the leaf mines and pupate on the leaf surface or, more commonly, drop from the plants to land in cracks in the soil. Many generations may occur each year, and the entire life cycle can be completed in less than 3 weeks when the weather is	Use yellow and green sticky traps to monitor and reduce populations. Use microtunnel covers to exclude leaf miners. Conserve natural enemies. Parasitic wasps normally control leaf miners, if not killed by pesticide overuse. Rotate with non-host crops and plan the arrangement of fields so that old infested fields do not provide a reservoir of infestation for subsequent crops. Destroy leaf miner pupae in the soil by plowing and tilling, by solarization, and, on	No reasonable treatment threshold Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) spinosad (Laser 480 EC) neem seed extract

Table 18. Okra/Gombo			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	warm. Leaf miners can reduce the plant's photosynthetic capacity, render edible leaf portions unmarketable, and provide an entrance for pathogenic organisms.	heavy soils, by flood irrigation.	garlic extract acétamipride (Titan 25 EC)
Cotton stainers/ seedbugs (*Dysdercus spp.*, *Oxycarenus spp.*) (Insecte de la graine du coton)	Long, 1-1.5 cm, red-yellow-black bugs that feed on plant seeds. They feed by injecting digestive saliva and using piercing-sucking mouthparts to suck up dissolved seed contents. Microorganisms also enter the feeding wound, further damaging the seed.	Use resistant varieties. Water and fertilize seedlings to maintain vigor to resist these bugs. Control weeds in and around the crop. Grow okra away from cotton and Hibiscus crops.	At flowering, monitor 20 plants and treat if 10% of the plants have seed feeding bugs. Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract

Table 18. Okra/Gombo			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			acétamipride (Titan 25 EC)
Spider mites (*Tetranychus spp.*) (Araignée rouge)	Mites are tiny 8-legged acarids that feed with piercing mouthparts, in groups on leaf undersides. Spider mites usually produce webbing to protect themselves. Extensive feeding causes leaf wilt and death, and is exacerbated by warm dry weather and drought. First symptoms of spider mite feeding are usually clusters of yellow spots on the upper surface of leaves, which may also appear chlorotic and get a speckled or mottled appearance. Attacked leaves turn bronze, or rusty, purple or yellow brown color, and stems turn brown. Fruits can crack.	Use resistant varieties. Water and fertilize seedlings to maintain vigor to resist mites. Control weeds in and around the crop. Grow okra away from cotton and Hibiscus crops.	Three weeks after crop emergence, sample 20 plants weekly and treat when 30% of leaves show mites. neem seed extract garlic extract chili extract abamectine (Abalone 18 EC, Acarius 18 EC, Bomec 18 EC, Vertimec 18 EC)
Nematodes: Root-knot, Reniform, Sting (*Meloidogyne spp., Rotylenchulus spp.,*	Microscopic nematodes feed within plant root zones on newly developed roots. Root-knot nematodes enter and cause galls of up to 3	Use resistant varieties. Do weed management in field.	No reasonable treatment threshold.

Table 18. Okra/Gombo			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Belonolaimus spp.) (Nématodes)	cm in diameter to appear on roots as quickly as a month after planting. Reniform nematodes stick their stylet into the root, with a kidney-shaped body protruding. Sting nematodes live entirely outside the roots, feeding on root hairs, tips and edges. Nematode feeding interferes with the flow of water and nutrients to the plant, and makes wounds that act as entry points for pathogens. Infected plants are prone to wilt in hot weather, and respond poorly to fertilizer; young plants may experience reduced vigor, slow growth, and stunting.	Use crop rotation, fallow, and intercropping, mixed cropping or cover cropping with non-host crops. Field solarization (a transparent polyethylene film is laid over moist soil for a 6-to-12-week period to heat). Flood the plot. Avoid growing on a known infected plot. Use 2 kilos of compost per plant to enhance soil organic matter and microbial composition. Plant Marigold (pyreuthrum flower) and plow under the soil 2 months later. Use Tithonia diversifolia as organic compost. Do “biofumigation” of the soil by growing, grinding/macerating and plowing under crucifers/mustards, and covering the soil with	fluopyram (Velum Prime 400 SC)

Table 18. Okra/Gombo			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		plastic, if available, until just before planting. Rotting crucifers produce toxic gasses that kill nematodes, and covering with plastic increases efficacy. Do not allow irrigation water to flow from an infested field to other fields without impounding. Prevent animal grazing and movement from infested to uninfested fields. Sanitation: Remove or compost crop residues after harvest, let them dry out before destruction. Do crop rotation to non-host or nematode-suppressing crops like pyrethrum flower, common vetch, rapeseed, Chrysanthemum, velvet bean, partridge pea, castor bean, or sesame.	

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Viruses: Okra yellow vein mosaic virus, OkYVMV, transmitted by whiteflies Okra leaf curl virus, OkLCV, tramsitted by whiteflies Okra mosaic virus, OkMV, transmitted non-persistently by whiteflies and flea beetles	Yellowing and curling of leaves, vein thickening, reduction in leaf size, brittleness and thickening. Leaves may also become leathery, turning dark green compared to uncurled leaves. Major constraint to production in the Sahel.	For whitefly vector prevention: Do intercropping and interplanting crops Use yellow sticky traps for monitoring. After the last harvest, destroy all crop residues. Ensure good growing conditions for the crop. Avoid application of high doses of nitrogen fertilizer.	No reasonable treatment threshold For vector control: Use seed treated with imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS-- all seed treatments done only by professionals) neem seed extract garlic extract chili extract acétamipride (Titan 25 EC) spinosad (Laser 480 EC)
Fusarium root rot (*Fusarium spp.*)	Soil-borne pathogens that infect seedlings, leading to red-brown lesions on stems and roots, causing them to wilt and die.	Use disease-free seed. Plant on raised-bed. Obey optimal spacing; avoid overc-rowding.	No treatment threshold Use seed treated with

Table 18. Okra/Gombo			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	A major constraint to production in the Sahel.	Avoid water stress by planting early. Amend the soil with compost.	difenoconazole (Ortiva Top, Apron Star 42 WS) mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP) thirame (Caiman Rouge P, Calthio Mix 485 WS, Insector T, Momtaz 45 WS--seed treatments only by professionals) neem seed extract tébuconazole + trifloxystrobin (Nativo 300 SC)
Powdery mildew (*Erysiphe cichoracearum*)	Powdery mildew fungi produce white powdery growth consisting of large numbers of fungal spores, which are spread by wind. The disease can spread very rapidly. The pathogens generally overseason on weeds.	Use resistant varieties Remove weeds. Avoid late-season applications of nitrogen fertilizer.	No treatment threshold neem seed extract

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	Powdery mildews are severe in warm, dry climates because the fungus does not need the presence of water on the leaf surface for infection to occur. However, the relative humidity of the air needs to be high for spore germination. Therefore, the disease is common in crowded plantings where air circulation is poor and in damp, shaded areas. Young, succulent growth usually is more susceptible than older plant tissues.	Avoid overhead watering. Remove and destroy all infected plant parts.	azoxystrobin (Azox, Ortiva 250 SC, Ortiva Top) tébuconazole + trifloxystrobin (Nativo 300 SC)
Bacterial wilt (*Ralstonia solanacearum*) (Flétrissement bactérien)	The disease causes rapid wilting and death of the entire plant without any yellowing or spotting of leaves.	Use resistant varieties. Practice long-term (5-year) crop rotation. Use clean planting material and transplants. Establish plantings in non-infected soil. Remove wilted plants from the field and destroy them.	No treatment threshold No bactericides are recommended

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Cercospora leaf spot/black mold (*Cercospora abelmoschi*)	Spores from the infected field or plants are blown by the wind to other plants. The plants show mycelial growth) on the underside of the leaves. Symptoms on older maturing leaves include brown spots with yellowing and grows as a sooty to dark oily mold on the underside of leaves. When infection is severe and conditions are high humidity, it also appears on upper surface of infected leaves. Seriously infected foliage rolls, turns brown, wilts, dries and falls to the ground.	Use resistant and tolerant varieties. Use clean seed. Do not overcrowd plants; keep them from touching. Avoid overhead irrigation. Water early in the morning. Crop rotation for 2-3 years with sorghum, maize, or fodder plants. Rotate with baby corn, maize, small grains or pulses. Remove and destroy (burn) dropped leaves, crop residues and heavily infected plants.	No treatment threshold Spray fungicides late in the afternoon: mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP) tébuconazole + trifloxystrobin (Nativo 300 SC) neem seed extract

Allium Crops: Onions/Garlic

Onions, *Allium cepa*, and garlic, *Allium sativum*, probably were domesticated in central Asia, Iran and West Pakistan, from where they spread on trade routes to Africa well before European invasion. In the tropics, the varieties that do well are grown as annuals and they produce seed within the first year of growth. Onions are particularly suited to smallholder farming in most countries, and are grown small scale in home gardens, for local market sale and export markets. Onions are used for salads, pickling, and cooking in sauces with tomato, as well as in traditional medicine, as a diuretic. If farmers have irrigation, they will grow onions for the fresh market but rainfed onion is grown for seed.

Table 19. Allium Crops: Onions/Garlic			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Onion thrips (*Thrips tabaci*)	Thrips are tiny, 1-2mm, dark slender insects with fringed wings, best seen with a hand lens. They are seasonally transported northwards from more-humid coastal countries with the rain/wind storms. They feed by puncturing plant tissue and sucking out the cell contents. Nymphs and adults feed under leaf folds in protected inner leaves near the bulb. High populations of thrips can reduce both yield and storage quality of onions. Thrips are most damaging when they feed during the early bulbing stage of plant development. Major constraint to production in the Sahel.	Natural enemies such as minute pirate bugs, lacewing or predatory thrips control thrips in the crop. Eliminate other host plants on or near the crop. Sanitation: Remove and destroy infested crop residues.	No reasonable treatment threshold Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract garlic extract chili extract acétamipride (Titan 25 EC)
African bollworm (*Helicoverpa armigera*) (Foreur de la gousse)	Bollworms are large caterpillars, 12-20 cm long, brown-green, with stripes on each side. They have stiff hairs on each abdominal segment that differentiate them from cutworms and armyworms. Adults	Check for and conserve natural predators and parasites that can control large numbers	No reasonable treatment threshold Use seed treated

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	are brown moths, 1.5-2 cm long. White eggs are laid in small groups on leaves. High populations inflict significant damage, particularly during droughts, if larvae consume flowers and pegs during podding. Vigorously growing plants with adequate available moisture are better able to replace damaged leaves and compensate for flower and pod damage. Major constraint to production in the Sahel.	of Helicoverpa larvae. Use insect pheromone traps near the field to monitor for presence, to know when to monitor for eggs. Two weeks before planting, remove weeds and grasses to destroy larvae and adults harboring in those weeds and grasses Plow, disc and harrow fields at least two times before sowing seeds to expose pupae to predators. Sow seeds thinly and remove competing weeds to produce vigorous plants, which are more likely to withstand pests and diseases. Avoid planting crops successively that are hosts like corn, cotton, sorghum, tobacco and soybean.	with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract garlic extract BT (Batik WG, Bio K 16) spinosad

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Leaf miners (*Liriomyza spp.*)	Leaf miners attack a wide variety of vegetable crops, particularly in the seedling stage, often grown in proximity to cole crops. Adults are tiny black flies with a bright yellow spot on their thorax. Females puncture leaves to feed on plant sap and lay eggs within the leaf tissues. After 2 to 4 days, the eggs hatch and larvae feed between the upper and lower surface of leaves, as they move in their tunnels. Larvae emerge from the leaf mines and pupate on the leaf surface or, more commonly, drop from the plants to land in cracks in the soil. Many generations may occur each year, and the entire life cycle can be completed in less than 3 weeks when the weather is warm. Leaf miners can reduce the plant's photosynthetic capacity, render edible leaf portions unmarketable, and provide an entrance for pathogenic organisms.	Use yellow and green sticky traps to monitor and reduce populations. Use microtunnel covers to exclude leaf miners. Conserve natural enemies. Parasitic wasps normally control leaf miners, if not killed by pesticide overuse. Rotate with non-host crops and plan the arrangement of fields so that old infested fields do not provide a reservoir of infestation for subsequent crops. Destroy leaf miner pupae in the soil by plowing and tilling, by solarization, and, on heavy soils, by flood irrigation.	Treat if more than 25 % of plants show damage. Use seed treated with thiamethoxam (Apron Star 42 WS) or imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract garlic extract acétamipride (Titan 25 EC) spinosad (Laser 480 EC)
Bacterial soft rot *Pectobacterium*	Harvested infected bulbs rot in storage. Yellow tissue turns brown.	Avoid overhead irrigation once onions	No treatment

Table 19. Allium Crops: Onions/Garlic			
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carotovorum subsp. carotovorum (syn. *Erwinia carotovora subsp. carotovora*) (Pourriture bactérienne)	This leads to softening and water soaking of one or more of the inner fleshy scales.	start to bulb. Provide for quick drying following topping, especially if temperatures are high. Harvest only after onion tops are well matured. Control insect pests such as the onion maggot.	threshold neem seed extract
Fusarium wilt (*Fusarium oxysporum f. sp cepae*) (Flétrissement fusarien)	Soil-borne pathogen that infect seedlings, leading to red-brown lesions on stems and roots, causing them to wilt and die. Yellowing of the top of the leaves and browning at the bottom of the bulb. Browning and rotting of roots and appearance of white-pink.	Use tolerant varieties. If infections are high, rotate out of onions for 3-4 years.	No treatment threshold Apply to soil: neem seed cake
Damping off fungi (*Phytophthora spp., Pythium spp., and Rhizoctonia spp.*)	Soil-borne pathogens that infect seedlings, leading to red-brown lesions on stems and roots, causing them to wilt and die. Constitute a major constraint for onion production during the rainy season. Major constraint to production in the Sahel.	Use treated seeds. Crop rotation. Avoid wet soils. Favor good drainage and good soil aeration. Water only when soil is dry.	No treatment threshold Use seed treated with mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP)

Table 19. Allium Crops: Onions/Garlic			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			thirame (Caiman Rouge P, Calthio Mix 485 WS, Insector T, Momtaz 45 WS--seed treatments only by professionals) difenoconazole (Ortiva Top, Apron Star 42 WS) tébuconazole + trifloxystrobin (Nativo 300 SC) neem seed extract
Pink root rot (*Pyrenochaeta terrestris* and *Fusarium spp*) (Maladie des racines roses)	Soil-borne pathogen that infects seedlings, leading to pink lesions on stems and roots, causing them to wilt and die. Pink and red roots and dried out. Infected roots first turn light pink, then darken through red and purple, shrivel, turn black, and die. Eventually stunted plants. Major disease constraint for onion production.	Use resistant varieties. (resistance may be overcome if soil temperatures of 28°C or higher occur. Schedule planting so that the bulk of the root growth occurs prior to reaching soil temperatures that favor disease development (24-28°C)	No treatment threshold The best management option is the use of resistant varieties. The following techniques can vary in terms of

Table 19. Allium Crops: Onions/Garlic			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		Rotate out of infected onion fields for 4-6 years. Remove weeds and plant residues. Plant in friable, well-drained soils. Do soil solarization. Ensure good soil tilth and fertility. Avoid planting onions after cereals.	effectiveness due various field conditions. Apply to soil: neem seed cake tébuconazole + trifloxystrobin (Nativo 300 SC)
Purple blotch (*Alternaria porri*)	Purple blotch fungus causes oval-shaped tan and deep purple lesions on leaf blades. Along the edge of the blade, yellow streaks, which turn brown, extend in both directions from the lesion. Later, lesions with concentric zones may girdle and kill leaves and seed stems.	Use resistant varieties. Disinfect seeds. Use a crop rotation of 3-4 years. Avoid watering the foliage at the end of the day or at night. Do not plant new fields near existing fields with blight symptoms.	No treatment threshold Use seed treated with thirame (Caiman Rouge P, Calthio Mix 485 WS, Insector T, Momtaz 45 WS--seed treatments only by professionals)

Table 19. Allium Crops: Onions/Garlic			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		If possible, use furrow irrigation. Remove and destroy crop debris.	garlic extract mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP) chlorothalonil (Jumper 75 WG) tébuconazole + trifloxystrobin (Nativo 300 SC)
Black mold (*Aspergillus niger*) (Moisissure noire)	Black colored mold infects harvested bulbs.	Early harvest. Harvest when conditions are dry. Remove dead onion tissue to improve storability. Low storage temperatures (ideally <13°C) are key in its suppression. Other important factors are good curing of onions in the field and avoid bruising and injury of the bulbs in storage.	No treatment threshold Use seed treated with thirame (Caiman Rouge P, Calthio Mix 485 WS, Insector T, Momtaz 45 WS--seed treatments only by professionals) difenoconazole (Ortiva Top, Apron Star 42 WS)

Table 19. Allium Crops: Onions/Garlic			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			Properly managed fungicidal applications to control other pathogens during the growing season will reduce also the incidence of black mold.
Weeds	See weed descriptions above, under maize	See weed preventive tools above, under maize	For commercial farms, use cléthodim (Select 120 SC) oxadiazon (Oxo 250 EC) oxyfluorfene (Goal 2E)

Senna Plant/Java Bean

Java Bean, *Senna obtusifolia*, is grown for leaves which are fermented and dried or cooked into a stew to eat as a local spinach. Dried fermented leaves are mixed with onions and okra.

- No serious pests or diseases listed

Sesame (also high-value, export)

Sesame, *Sesamum indicum*, is likely originally from India as well as East Africa, and is the oldest of the commercial oil seeds. Sesame is resistant to drought, tolerant to insect pests and diseases, and a low-cost alternative specialty crop. Sesame is grown as a cash crop and has a large market as an oil crop. White sesame seeds are in demand on conventional and on ecological markets, due to a higher oil content than pigmented varieties. Sesame seeds are either consumed directly as a highly nutritious foodstuff or processed by the confectionery and bakery industries. By-products of oil extraction are an excellent protein component to mix into animal feed.

Sesame is an excellent rotation crop wtih millet, groundnut, and sorghum. It reduces nematode populations and is also an excellent soil builder as it improves the texture and moisture retention and lessens soil erosion. The composted sesame leaves left on the soil bind the ground and retain soil moisture better for planting the next crop. Sesame hay, if carefully dried, can be used as fodder. The oil is a clear edible oil with a pleasant taste and a very good long shelf life if properly refined.

Table 20. Sesame

Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
White fly (*Bemisia tabaci*) (Mouche blanche) transmit leaf curl virus (LCV)	Whiteflies are tiny, 2 mm, white, insects with piercing-sucking mouthparts. They occur in groups on the undersides of leaves, laying eggs, which develop into nymphs that also suck plant sap from the leaves. Outbreaks, leading to leaf-wilting and death under drought stress, often occurs when the natural biological control is disrupted by over-use of pesticides.	Do intercropping and interplanting crops Use yellow sticky traps for monitoring. After the last harvest, destroy all crop residues. Ensure good growing conditions for the crop. Avoid application of high doses of nitrogen fertilizer.	If LCV is present, treat for whiteflies if more than 1 is found per plant. Use seed treated with imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals)

Table 20. Sesame			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			neem seed extract garlic extract chili extract acétamipride (Titan 25 EC) spinosad (Laser 480 EC)
Green peach aphid (*Myzus persicae*) (Puceron vert du pêcher)	Aphids are major pests that passively feed on sap of phloem vessels in plants. Once a phloem vessel is punctured, the sap, which is under high pressure, is forced into the aphid's food canal. They are soft-bodied, and have little protection from predators and diseases. Small populations may be relatively harmless, but heavily infested plants usually have wrinkled leaves, stunted growth and deformed capsules. Due to hot temperatures in Niger they can undergo more than 40 generations per year where one generation takes only 9 days, each female producing 20 offspring.	Many natural enemies and parasites control aphids. Eliminate ant colonies near field. Do not over-apply nitrogen fertilizers. Aluminum foil or gray mulches deter aphids.	No treatment threshold. Use seed treated with imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract garlic extract chili extract

Table 20. Sesame			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Sesame webworm (*Antigastra catalaunalis*) (Pyrale)	The sesame webworm is a major pest that feeds on the sesame crop from seedling to flowering and capsule stages. In a young crop, the webworm makes webs in the upper portion of plant to draw together leaves offering protection while it feeds. At flowering stage, it feeds on the flowers and at capsule stage, it bores into the capsules to consume the developing seeds. As a result, 20 to 50 **%** loss of yield can occur, particularly from an early infestation of the crop. One to three larvae are enough to denude a full-grown plant within 24 to 48 hours. Most serious damage is caused during the flowering and podding period. A generation takes just over three weeks to complete. It passes the dry season in dormancy in crop residues.	Use resistant varieties. Use intercropping.	Treat if defoliation reaches 25%. Use seed treated with imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) spinosad (Laser 480 EC) neem seed extract
Sesame gall midge (*Asphondylia sesami*) (Cécidomyie du sésame)	The sesame gall midge is usually a minor pest, but occasionally high infestations occur resulting in considerable crop losses. The adult is a 5 mm long red-bodied midge (mosquito-like fly). Female midges lay eggs along the veins of terminal sesame leaves. The larvae are typical	Use resistant varieties (prefer plants with black capsules to ones with green capsules). Synchronous planting.	Treat if density reaches one gall per plant. Use seed treated with imidaclopride (Calthio Mix 485 WS, Insector T,

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	maggots; they are whitish to orange in color, legless and with body tapering exteriorly and grow up to 4 mm in length. Maggots feed inside the floral buds and young capsules leading to formation of galls, where they pupate. The gall midge attacks during flowering and become particularly abundant if planting is staggered or varieties of different maturity periods come to flower over a long period, as this leads to multiple generations to develop.	Intercrop with mungbean, pearl millet, or groundnut. Conserve predator and parasitic wasp natural enemies by using selective insecticides.	Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract garlic extract acétamipride (Titan 25 EC)
Leafhopper (*Orosius orientalis*) (Cicadelle)	This small, 5-7 mm, wedge-shaped insect is light green to yellow. Both adults and nymphs pierce and suck undersides of leaves feeding on phloem. Toxins passed into plants at feeding sites produce a symptom called hopper burn, whereby leaves yellow near the center and tips, and plant growth can be stunted, resulting in reductions in yield and grade. Damage is worse when plants are stressed, and young.	Do intercropping. Use resistant varieties. Avoid growing sesame near okra, cotton or Solanaceous crops.	No reilable treatment threshold. Use seed treated with imidaclopride (Calthio Mix 485 WS, Insector T, Momtaz 45 WS--all seed treatments done only by professionals) neem seed extract

Table 20. Sesame			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
			garlic extract chili extract acétamipride (Titan 25 EC)
Spider mites (*Tetranychus spp.*) (Tétranyque)	Mites are tiny 8-legged acarids that feed with piercing mouthparts, in groups on leaf undersides. Spider mites usually produce webbing to protect themselves. Extensive feeding causes leaf wilt and death, and is exacerbated by warm dry weather and drought. First symptoms of spider mite feeding are usually clusters of yellow spots on the upper surface of leaves, which may also appear chlorotic and get a speckled or mottled appearance. Attacked leaves turn bronze, or rusty, purple or yellow brown color, and stems turn brown.	Use resistant varieties. Water and fertilize seedlings to maintain vigor to resist mites. Control weeds in and around the crop.	No treatment threshold. neem seed extract garlic extract chili extract abamectine (Abalone 18 EC, Acarius 18 EC, Bomec 18 EC, Vertimec 18 EC)
Damping off fungi (*Pythium spp., Sclerotium spp., Fusarium spp.*)	Soil-borne pathogens that infect seedlings, leading to red-brown lesions on stems and roots, causing them to wilt and die.	Use disease-free seed. Plant in well-drained soils. Plant on raised beds.	No treatment threshold.

Table 20. Sesame			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		Obey proper plant spacing. Avoid water stress by planting early. Amend the soil with compost.	Treat the seed with: thirame (Caiman Rouge P, Calthio Mix 485 WS, Insector T, Momtaz 45 WS--seed treatments only by professionals) mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP) difenoconazole (Ortiva Top, Apron Star 42 WS) tébuconazole + trifloxystrobin (Nativo 300 SC) neem seed extract

Table 20. Sesame			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Leaf spot (*Alternaria spp*.)	Small, dark brown water soaked, round to irregular lesions, with concentric rings, 1-8 mm in diameter appear on the leaves. The lesions may also appear on the midrib and veins of the leaves.	Use resistant varieties. Disinfect seeds. Use a crop rotation of 3-4 years. Avoid watering the foliage at the end of the day or at night. Do not plant new fields near existing fields with blight symptoms. If possible, use furrow irrigation. Remove and destroy crop debris.	Use seed treated with thirame (Caiman Rouge P, Calthio Mix 485 WS, Insector T, Momtaz 45 WS--seed treatments only by professionals) garlic extract mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP) tébuconazole + trifloxystrobin (Nativo 300 SC)
Phyllody mycoplasma-like organism (MLO) transmitted by leafhoppers	This mycoplasma disease causes stunted plants. The capsules abort and open, exposing developing seeds. Flowers turn green, leaf-like, and proliferate. Yellowing, cracking of seed capsules, germination of seeds in the capsules, formation of dark exudates on the foliage. Abundant abnormal branches	Do intercropping. Use tolerant varieties. Roguing of infected plants. Adjust the planting time to one where disease prevalence is low.	No treatment threshold. Use the following to control leaflhoppers:

Table 20. Sesame			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	bend down. Plants look like a witch's broom.	Control the leafhopper vector with insecticides.	neem seed extract garlic extract chili extract acétamipride (Titan 25 EC)
Leaf curl virus, LCV, transmitted by whiteflies	Curling of leaves, vein thickening, reduction in leaf size, brittleness and thickening. Leaves may also become leathery, turning dark green compared to uncurled leaves.	Place fine mesh row covers over the crop. All other measures center on controlling the vector.	Control whitefly, see above.

Fruits

Citrus

Citrus trees, *Citrus species*, evolved and was domesticated in south-western China and Vietnam. Fruits include oranges, Mandarins, lemons, limes, grapefruit and pomello. Many of these are grown in Africa. They are usually eaten fresh, as well as used for juice. Essential oils can be extracted from citrus peels and applied to crops as insect antifeedants or repellents.

Table 21. Citrus			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Citrus leaf miner (*Phyllocnistis citrella*)	The adult of the citrus leaf miner is a tiny, 2mm, silver moth with a dark spot on each wingtip. Eggs are laid in the leaf. Larvae meander through a serpentine mine, with a characteristic center-line of dark frass, usually on the bottom of the leaf. Larvae are tiny, 3mm, translucent greenish-yellow. The pupa is found in a pupal cell at a curled leaf margin. Adult moths are active diurnally and in the evenings. A major constraint that limits production in the Sahel.	Several predators and parasites feed on leaf miner larvae. Promote and protect biological control. Use a pheromone trap for monitoring.	No treatment threshold. neem seed extract garlic extract
African Citrus psylla (*Trioza erytreae*) can transmit Huang Long Bing (HLB) bacteria	Adult psyllids are 3 to 4 mm long with a mottled brown body, with a black head. Adults and nymphs feed by piercing-sucking mouthparts. Nymphs produce white waxy excretions.	Use and plant only certified clean tree stock. Place imported and diseased tree stock under quarantine. Install the citrus nurseries in the low land (1400 m of altitude) where the	No treatment threshold. neem seed extract chili extract garlic extract[12]

[12] If HLB transmission is an issue, these pesticides may be too slow acting.

Table 21. Citrus			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		vector population is low Several natural predators feed on and control the citrus psylla. Sanitation: Remove and destroy infested and infected trees.	
Cloudy winged white fly, *Aleurolobus citrifolii*	Whiteflies are tiny, 2 mm, white, insects with piercing-sucking mouthparts. They occur in groups on the undersides of leaves, laying eggs, which develop into nymphs that also suck plant sap from the leaves. Outbreaks, leading to leaf-wilting and death under drought stress, often occurs when the natural biological control is disrupted by over-use of pesticides.	Do intercropping and interplanting crops Use yellow sticky traps for monitoring. After the last harvest, destroy all crop residues. Ensure good growing conditions for the crop. Avoid application of high doses of nitrogen fertilizer.	No treatment threshold. neem seed extract garlic extract chili extract spinosad (Laser 480 EC)
Citrus Brown Aphid, *Toxoptera* (=*Aphis) citricidus*	On newly established trees and on new growth flushes on mature trees, it is not uncommon for aphids to cause	Avoid pruning live branches more than one time a year, to reduce new leaf flushes.	Treatment is usually not warranted because citrus can tolerate extensive leaf

Table 21. Citrus			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	curling of leaves and produce honeydew.	Several coccinellid and syrphid predators, parasites and fungal diseases control aphids below damaging levels. Use upwind barrier crops of Lemongrass and Sugarcane. Do not apply large amounts of nitrogen while aphids are present. Remove 'water sprouts' (vigorous shoots that grow above graft unions) and 'suckers' (grow below graft unions). Use pheromone traps for monitoring and mass trapping. Sanitation: remove crop debris and weeds.	curling without yield effects.
Citrus red scale, *Aonidiella aurantii*	Heavy adult scale and mealybug feeding can reduce citrus plant vigor and cause fruit drop and twig dieback. The honeydew excreted by	Use and plant only certified clean tree stock.	No treatment threshold.

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	scales and mealybugs may also promote sooty mold growth, reducing photosynthesis and ruining fruit appearance.	Planting and growth: Many predators and parasites control scales, including beetles, bugs, green lacewings and predatory mites. Monitor for presence of scales and in the summer, crawlers. Provide plants with good growing conditions and especially appropriate irrigation. Prune branches to open them up to light, sun and predators. Sanitation: Prune off and destroy heavily infested branches. Manage ants that tend the scales by placing tanglefoot around the tree trunk. Prune off and destroy heavily infested branches.	neem seed extract garlic extract chili extract

Table 21. Citrus			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Citrus mealybug, *Pseudococcus citri*	A small, 3mm, white waxy covered insect with piercing-sucking mouthparts. Eggs are deposited as white, cottony masses on the trunk and stems of citrus trees, giving the appearance of cotton. Feeding results in distorted, wilted, and yellowed leaves, premature leaf drop, stunted growth, and occasional death of infested plant parts or plants. Honeydew falls on leaves and fruits below, resulting in the growth of sooty mold. Feeding under and adjacent to the button of oranges results in development of hard lumps and fruit drop. Mealybugs are transported on the wind, on ants, bird's feet, and orchard workers.	Mealybug populations are naturally regulated by predators and parasitic fungi. Prune trees so that branches do not touch. Thourough cleanining of harvest equipment and fruit sacks.	No treatment threshold. neem seed extract garlic extract chili extract
Fruit Flies, *Dacus species*	Adult fruit flies are 0.4 cm long. The general color of the body is yellowish with a tinge of brown, and some of the markings on the wings. Damage to crops include oviposition in fruit and soft tissues of vegetative parts of certain plants, feeding by the larvae, and decomposition of	Use resistant grafted resistant planting materials. Remove fruit as it matures. Sanitation: Prune trees to open the canopy. Cleaning up	No reasonable treatment threshold. neem seed extract garlic extract

Table 21. Citrus			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	plant tissue by invading secondary microorganisms. Fruit fly females lay eggs under the epidermis of the fruit. Several eggs may be laid on each fruit. Maggots remain in fruits until fully grown (from 2 to 3 weeks), after which they drop to the soil to pupate.	and destroy dropped infested citrus.	spinosad (Laser 480 EC)
Huang Long Bing HLB), or citrus greening disease (*Candidatus Liberibacter africanus*) transmitted by African Citrus psylla (see above)	HLB is distinguished by the symptoms of yellowing of the veins and adjacent tissues; followed by splotchy mottling of the entire leaf, premature defoliation, dieback of twigs, decay of feeder rootlets and lateral roots, and decline in vigor, followed by the death of the tree. Affected trees have stunted growth, bear multiple off-season flowers (most of which fall off), and produce small, irregular-shaped fruit with a thick peel that remains green at the bottom and tastes bitter. Common symptoms can often be mistaken for nutrient deficiencies; however, the distinguishing factor between nutrient deficiencies is the pattern of symmetry. Nutrient deficiencies tend to be symmetrical along the leaf vein margin, while HLB has an asymmetrical yellowing around the vein. The most noticeable	Use of certified disease-free planting materials is essential to minimize spread. Budwood sources and nursery production is carried out under psyllid-proof enclosures and are certified HLB free. Weekly scouting for greening infected trees should be done routinely so that infected trees can be removed. Sanitation: Remove infected trees immediately upon discovery and diagnosis.	Before removing infected trees, spray with a foliar insecticide such as spinosad (Laser 480 EC) or diméthoate (Methoate 40 EC) or malathion (Fyfanon 880 EC) or acétamipride (Titan 25 EC) to eliminate the psyllid vector, which will try to move to other trees.

Table 21. Citrus			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	symptom of HLB is greening and stunting of the fruit, especially after ripening.		
Citrus Slow Decline Disease, caused by citrus root nematode, *Tylenchulus semipenetrans*	Citrus root nematode is found in most citrus production areas and diverse soil textures worldwide. Their feeding strategy is semi-endoparasitic and has a very narrow host range. Recently planted orchards will not show symptoms until nematode populations increase to at or above 2000 individuals per 100 cc of soil. Symptoms are stronger in established orchards with trees stressed by suboptimal growing conditions, drought, or root stunting and decay induced. These nematodes are considered as major plant-parasitic nematode because they can cause 10-30% losses reported on citrus trees. They parasitize other hosts such as olive, grape, persimmon and lilac	Use resistant rootstock (Swingle citrumelo). Use certified propagative citrus plants free from nematodes. Exclude nematodes by using certified nematode-free nursery citrus stock. Exclude nematodes by using only certified nematode-free soil. Prevent injury by using resistant varieties.	No reasonable treatment threshold. fluopyram (Velum Prime 400 SC)

Table 21. Citrus			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Withertip/Anthracnose (*Colletotrichum gloeosporioides*)	Anthracnose is a primary colonizer of injured and senescent tissues. The organism grows on dead wood in the canopy, and it spreads short distances by rain splash, heavy dew, and overhead irrigation. Common symptoms are a circular, flat area, light tan in color with a prominent purple margin. At a later phase of infection, fruiting bodies of the fungus tiny dispersed black flecks, will show. Fruit lesions are brown-black spots of 1.5 mm or greater diameter. The decay is usually firm and dry but if deep enough can soften the fruit. If kept under humid conditions, the spore masses turn pink-salmon, but if kept dry, the spores appear brown to black. Causes post-bloom fruit drop.	Infects weakened twigs, so maintain tree vigor. Sanitation: Prune and remove and destroy deadwood. Immediate storage of packed fruit at temperatures below 40°F will help suppress development of anthracnose.	No treatment threshold. azoxystrobin (Azox, Ortiva 250 SC, Ortiva Top) tébuconazole + trifloxystrobin (Nativo 300 SC)
Root rots/wilt/foot rot: Phytophthora gummosis (*Phytophthora citrophthora* and *P. parasitica*); Fusarium (*Fusarium spp.*);	The most serious soil-borne disease of citrus. A visible sign is gum oozing from small cracks in the infected bark around the bud- union give the affected trees a bleeding appearance. This gum is diluted and disappears after heavy rains. Severely affected trees have yellow foliage that eventually drops and twigs die-	Use tolerant or resistant rootstocks (Trifoliate orange, Swingle citrumelo, sour orange, rough lemon, and Carrizo and Troyer citranges are tolerant). Treat citrus seeds with hot water at 50°	No treatment threshold. Apply to soil: neem seed cake tébuconazole +

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Rhizoctonia (*Rhizoctonia spp.*)	back, with a crop of small fruits hanging from bare branches. The root cortex is attacked; feeder roots are destroyed when they turn soft and easily separate. In an advanced stage, the trunk becomes girdled and the affected trees decline and eventually die. Gummosis is favored by high moisture in the soil. In areas where the water table is not very deep, like the zones of the Dallol Bosso, Niger. A major constraint that limits production in the Sahel.	C (too hot for finger) for 10 minutes. Bud seedlings at a height of 25 cm and above, which will keep the bud union well above ground level. Avoid transplanting on heavy or poorly drained soils. Do not heap soil around the tree base. Avoid basin and flood irrigation. Plant trees on a berm or high enough so that the first lateral roots are just covered with soil. Use proper irrigation management and soil drainage. Remove the dark, diseased bark and a buffer strip of healthy, light brown to greenish bark 10mm around the margins of the infection, paint	trifloxystrobin (Nativo 300 SC)

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		wound with fungicide. Do not over irrigate and ensure water does not contact the bud union. Avoid injuries to roots and trunks when cultivating. Do not allow tall weeds to grow around citrus plants as they increase the relative humidity. Periodically prune to thin trees to increase air circulation. Do not replant citrus into planting sites where other citrus has been grown and proven unhealthy.	
PINK DISEASE (*ERYTHRICIUM* *(=Phanerochaete)* *salmonicolor*)	Produces sterile pink-white pustules of around 1 mm diameter on young green stems, sometimes with gummosis. The fungal mycelium spreads along the underside of the branch and pink-white mycelial pustules	Sanitation: Remove affected bark of the trunk and prune off diseased limbs.	No treatment threshold. no fungicides are recommended

Table 21. Citrus			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	appear through cracks in the bark and pores of the swollen lenticels, 1-8 cm behind the leading edge of the infection. Fungal hyphae penetrate the branch, killing distal tissues. Interveinal areas on leaves distal to the infection turn light green and then scorch brown from the margins. The affected leaves remain attached to the plant, giving an appearance of a broken branch. Open wounds turn to cankers and branch splits.	Sterilize tools between cuts and trees.	
Greasy spot (*Mycosphaerella citri*)	First symptoms appear on leaf undersides as are pale yellow, slightly raised lesions that darken over time to brown-black. On the upper leaf surface these appear as yellow-brown spots with yellow halos. On fruit, spots appear greasy green blemish with tiny black spots, which can merge, forming sunken pink-brown blotches.	Remove or bury infected leaf litter (within 4 weeks of a significant leaf drop). Modify tree architecture (skirting and thinning out upper branches) so that trees readily dry out after rain events. In wet regions cultural practices will not give adequate control and	No treatment threshold. difenoconazole (Ortiva Top, Apron Star 42 WS) neem seed extract garlic extract chili extract

Table 21. Citrus			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		fungicide sprays may become necessary.	
Citrus Tristeza Virus (CTV) transmitted by aphids	There are three distinct syndromes of CTV infection: quick decline, stem pitting, and seedling yellows. The most notorious is quick decline and is associated with the name Tristeza (Spanish for sadness), where the roots die. Leaves show chlorotic leaf flecking, vein clearing, leaf cupping, corking of leaf veins, and stem pitting. Fruits are reduced in size. Whole tree symptoms include thinning of foliage, twig dieback, retardation of growth and possible tree collapse.	Use tolerant rootstocks (Sweet orange, Cleopatra mandarin, Rough lemon, Rangpur lime and Trifoliate orange) Control aphid vectors (see aphids, above). Do not plant in heavy, water-logged soils. Post-harvest: Remove and destroy dead trees when they become unproductive. When grafting or topworking, use only certified, virus-free budwood.	No treatment threshold. Not economical to spray, no synthetic insecticides recommended.
Citrus canker (*Xanthomonas citri* subspecies *citri)*	Causes crater-like lesions and scabs on leaves, rind of fruits and on stems and shoots.	Use resistant varieties.	No treatment threshold.

Table 21. Citrus			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	Fruits have an exudate of resinous substances. Under dry conditions, the canker spot is raised, corky, spongy, and has a ruptured surface. Under moist conditions, lesions rapidly enlarge, unruptured with an oily appearance at the margin.	Do not move equipment or personnel from infected orchards of groves to uninfected orchards; disinfect all tools and clothes. Remove and burn heavily infected trees off-site. Control leaf miners.	no bactericides are recommended
Post-harvest green mold/blue mold Penicillium fruit rots (*Penicillium digitatum, P. italicum*)	This destructive fruit rot of stored citrus begins with symptoms including a soft water-soaked area on the peel that turns blue, followed by development of a circular colony of white mold at the margin. The fruit rapidly spoils and breaks down.	Sanitation: Remove and destroy molded fruit from orchard after harvest. Use careful harvesting and handling to avoid injury to fruit. Promptly eliminate molded fruit and green spores from pack house/storage. Use exhaust fans at storage house dumper to remove air and spores. Decayed fruit should never be re-packed	No treatment threshold. no fungicides are recommended

Table 21. Citrus			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		within the packinghouse. The pallets, packinghouse, and packingline, including the washer brushes, should be sanitized daily to eradicate inoculum. Aqueous solutions in drenchers and soak tanks should be treated continuously with a sanitizer, such as chlorine.	

Mango

Mango trees, *Mangifera indica*, were domesticated in India; from there they were spread by colonists to Africa and other regions of the world, where they did not have resistance to local conditions, pests and diseases. Fruits are grown for local consumption as well as in larger orchards for export as fresh mangoes, juice and dried mango.

Table 22. Mango			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Mango fruit flies (*Bactrocera*	Adult fruit flies are 4 to 7 mm long, brightly coloured, generally in yellow-brown patterns, with	Use resistant grafted planting materials.	No treatment threshold.

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Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
invadens, Ceratitis capitata, C. cosyra)	banded or spotted wings with yellow and brown margins. Females puncture mango skin and lay eggs in groups of 3-8. Larvae are small white maggots that feed on fruit flesh, causing fruit rot. They pupate in the soil under the tree. A major constraint that limits production in the Sahel.	Removal of fruit as it matures. Sanitation: Pruning trees to open the canopy. Clean up and destroy dropped and heavily infested (dimpled with ooze) mangoes at least twice a week during the fruit season, burn or bury at least 50cm deep. Pick overripe fruits, as they attract fruit flies. Physical methods include fruit fly traps and fruit bagging. Monitor fruit fly populations using traps with attractants.	neem seed extract garlic extract kaolin clay/aluminum silicate (Surround WP Crop Protectant) spinosad (Success Appat 0.24 CB) diméthoate (Methoate 40 EC) malathion (Invader-B-Lock)
Mango seed weevil (*Sternochetus mangiferae*)	The seed weevil adults feed on mango leaves, tender shoots or flower buds. Female weevils lay one egg in the young fruit. The larvae burrow through the flesh and into the seed, feeding on and destroying it. Larvae pupate and the adult beetle tunnels through the flesh and leaves a	Continuous monitoring to ensure timely intervention is important (a weevil attack can be detected by monitoring for egg-laying marks on	No treatment threshold. Insecticidal control is not recommended or used

Table 22. Mango			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	hardened tunnerl and hole in the fruit, making it unmarketable.	young fruit). Ensure orchard quarantine by restricting movement of fruit from old orchards or infested areas Apply sticky bands at the upper end of tree trunks when the trees start flowering to reduce migration of weevils to branches for egg laying. Sanitation by collecting and destroying or burying scattered mango seeds and fallen fruit.	
Mango scales (*Aulacaspis tubercularis*)	Mango scales are small, 3-5 mm round, immobile insects, covered with a white-gray waxy shell-like (scale-like) covering. Female scales have neither wings nor legs. Females lay eggs under their scale. Larvae are called crawlers, which emerge from the protective scale, and move in search of a feeding site, and cease	Natural enemies such as parasitic wasps control scales in the orchard. Eliminate other host plants on or near the plantation. Cut back on shade by pruning.	No treatment threshold. malathion (Fyfanon 880 EC) neem seed extract garlic extract

Table 22. Mango			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	movement. They suck sap on all above the ground plant parts. Aulacaspis tubercularis is called an armored scale, which does not excrete honeydew. The body of is red-brown. Females are covered with a white round shell, while males have a small rectangular shell with two groves. Feeding may cause yellowing of leaves, followed by poor growth, leaf drop, dieback of branches, blemishes and fruit drop. Heavily infested young trees may die.		chili extract
Mango mealybugs (*Rastrococcus invadens*)	Mango mealybugs, 3-5mm long, use piercing-sucking mouthparts to suck sap from roots, tender leaves, petioles and fruit. Severely infested leaves turn yellow and dry. Severe attack can result in leaf and flower drop, reduced fruit setting and young fruit drop. The foliage and fruit become covered with honeydew and sooty molds, which reduces its market value. The honeydew also attracts ants, which protect mealybugs from parasites and predators. The mango mealybug is covered with pale green-with waxy secretions and is transported on seedlings and fruit.	Flood orchard in October. In December rake soil around tree. Destroy affected parts at the beginning of the infestation. Heavily infested branches may be pruned to control the pest, especially on the tender branches before flowering begins. Conserve natural enemies like lady	No treatment threshold. neem seed extract garlic extract chili extract

Table 22. Mango			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		beetles, lacewings and other predators of mealybug. Control ants tending mealybugs. Undesirable ants can be kept out of the mango trees by banding the stems with sticky stripes. Remove tall weeds from orchard. Prune and open the canopy to air movement and sunlight.	
Thrips (*Selenothrips rubrocinctus*)	Thrips are tiny, 1-2mm, dark slender insects with fringed wings. They are seasonally transported northwards from Nigeria with the rain/wind storms. They feed by puncturing plant tissue and sucking out the cell contents. Nymphs and adults damage leaves and fruits, leaving a silver sheen of dead tissue.	Natural enemies such as minute pirate bugs, lacewing or predatory thrips control thrips in the crop. Eliminate other host plants on or near the crop. Sanitation: Remove and destroy infested crop residues.	No treatment threshold. neem seed extract garlic extract chili extract malathion (Fyfanon 880 EC)

Table 22. Mango			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Mango bud mites (*Eriophyes mangiferae*)	Mites are tiny 8-legged acarids that feed with piercing mouthparts, in groups on leaf undersides. Mango bud mite lives, sometimes in large numbers, in the buds and inflorescences of the host, causing bumpy, gall-like growths. Mite feeding stunts and malforms the buds, causes leaf drop and arrests plant growth, resulting in twiggy, stubby branches. Young trees are more heavily attacked. Yield can be greatly reduced. The mite usually occurs along with the pathogenic fungus *Fusarium mangiferae*. It is transmitted between trees and probably between tree parts by the mite, which enhances fungal penetration into the host via the feeding wounds.	Use more resistant varieties (Maya, Palmer, Keitt and Kent) Eliminate other host plants on or near the plantation. Maintain a clean plantation, remove weeds and heavily infested twigs and branches.	No treatment threshold. neem seed extract garlic extract chili extract abamectine (Abalone 18 EC, Acarius 18 EC, Bomec 18 EC, Vertimec 18 EC)
Mango white flies (*Aleurocanthus woglumi*)	Whiteflies are tiny, 2 mm, white, insects with piercing-sucking mouthparts. They occur in groups on the undersides of leaves, laying eggs, which develop into nymphs that also suck plant sap from the leaves. Outbreaks, leading to leaf-wilting and death under drought stress,	Conserve natural enemies by limiting sprays of synthetic pesticides.	No treatment threshold. neem seed extract garlic extract

Table 22. Mango			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	often occurs when the natural biological control is disrupted by over-use of pesticides.		chili extract acétamipride (Titan 25 EC)
Mango aphids (*Toxoptera odinae*)	This aphid is small, (1-2.5 mm long, brown, red-brown or black and covered with a light powdery dusting. These aphids live in clusters and suck sap on the underside of young leaves, petioles, young branches and fruit. Feeding causes rolling and twisting of the leaf midrib. Aphids produce honeydew, which falls onto leaves, twigs and fruit, and grows sooty mold. Coating of the fruit with sticky honeydew and black sooty mold reduces its market value.	Conserve natural enemies by limiting sprays of synthetic pesticides.	No treatment threshold. neem seed extract garlic extract chili extract
Anthracnosis (*Colletotrichum gloeosporioides)*	Anthracnose, causing black blotches on fruit, is the most wide-spread disease among mangoes, infecting fruits, and causing flower drop from young branches. Anthracnose usually co-occurs with mango scab caused by *Elsinoe mangiferae*- together, these destroy the fruit in field and post-harvest.	Sanitaiton: Removal and destruction of fallen and leftover mangoes and fallen leaves. Prune to promote ventilation of crown. Drop fruits in hot water (55 degrees C for 3-5 minutes) to kill the fungi, to reduce fruit rot in	No treatment threshold. difenoconazole (Ortiva Top, Apron Star 42 WS) mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP)

Table 22. Mango			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	A major constraint that limits production in the Sahel.	storage and transport.	tébuconazole + trifloxystrobin (Nativo 300 SC)
Mango powdery mildews (*Oídium mangiferae*; *Erysiphe* spp., *Sphaerotheca spp.)*	Powdery mildew fungi produce white powdery growth consisting of large numbers of fungal spores, which are spread by wind. The disease can spread very rapidly. The pathogens generally overseason on weeds. Powdery mildews are severe in warm, dry climates because the fungus does not need the presence of water on the leaf surface for infection to occur. However, the relative humidity of the air needs to be high for spore germination. Therefore, the disease is common in crowded plantings where air circulation is poor and in damp, shaded areas. Young, succulent growth usually is more susceptible than older plant tissues.	Use resistant varieties Remove weeds. Avoid late-season applications of nitrogen fertilizer. Avoid overhead watering. Remove and destroy all infected plant parts.	No treatment threshold. neem seed extract mancozeb[13](Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP) tébuconazole + trifloxystrobin (Nativo 300 SC) azoxystrobin (Azox, Ortiva 250 SC, Ortiva Top)

[13] Mancozeb gives some control if disease pressure is not high, but it’s certainly not the best choice for powdery mildews.

Table 22. Mango			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Mango dieback/gummosis (*Lasiodiplodia theobromae*)	Twigs die from the tips back into older wood, and leaves roll up, turn brown and drop, leaving dead branches stiking up. As the disease progresses, branches start drying up and dying one after another, resulting in death of the whole tree. Amber colored gum seeps out of infected tissues, oozing and dripping down the trunk. This fungus has a wide host range. The fungus is a common soil-borne saprophyte and wound parasite.	Prune diseased twigs 7-10 cm below the affected portion. Harvest mangoes with the stem.	No treatment threshold. no fungicides are recommended

Papaya

Papaya, *Carica papaya*, is native to southern Mexico and Central America, but has been transported to all tropical parts of the world, including Africa. Fruits are grown for local fresh consumption, as well as processing into juice mixes.

Table 23. Papaya			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Mites: Spider mites: Red spider mites (*Tetranychus* species);	Mites are tiny 8-legged acarids that feed with piercing mouthparts, in groups on leaf undersides. Spider mites usually produce webbing to	Use resistant varieties. Water and fertilize seedlings to	No treatment threshold.

Table 23. Papaya			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Broad mite (*Polyphagotarsonemus latus*); False spider mite (*Brevipalpus phoenicis*)	protect themselves. Extensive feeding causes leaf wilt and death, and is exacerbated by warm dry weather and drought. First symptoms of spider mite feeding are usually clusters of yellow spots on the upper surface of leaves, which may also appear chlorotic and get a speckled or mottled appearance. Attacked leaves turn bronze, or rusty, purple or yellow brown color, and stems turn brown. Fruits can crack. Broad mites are oval-shaped, seen by hand lens. A generation takes about 1 week under optimal conditions and females deposit 40 eggs. Dispersal is by winds and on the bodies of other insects especially whiteflies. Broad mite toxic saliva causes twisted, hardened and distorted growth at the terminal of the plant. Mites are usually seen on the newest leaves and small fruit. Severely infected fruits fall, and yield is significantly reduced.	maintain vigor to resist mites. Control weeds in and around the crop. Use high quality clean propagation material and monitor nursery for mites.	neem seed extract garlic extract chili extract abamectine (Abalone 18 EC, Acarius 18 EC, Bomec 18 EC, Vertimec 18 EC)

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	A major constraint that limits production in the Sahel.		
Mealybugs (*Planococcus spp.*)	A small, 3mm, white waxy covered insect with piercing-sucking mouthparts. Eggs are deposited as white, cottony masses on the trunk and stems of papaya, giving the appearance of cotton. Feeding results in distorted, wilted, and yellowed leaves, premature leaf drop, stunted growth, and occasional death of infested plant parts or plants. Honeydew falls on leaves and fruits, resulting in the growth of sooty mold. Mealybugs are transported on the wind, on ants, bird's feet, and orchard workers.	Mealybug populations are naturally regulated by predators and parasitic fungi. Thourough cleanining of harvest equipment and fruit sacks.	No treatment threshold. neem seed extract garlic extract chili extract
Aphids: Cotton aphid (*Aphis gossypii*); Green peach aphid (*Myzus persicae*)	Aphids attack terminal leaves, flower heads, and stems. Infested plants develop yellow foliage, may become dwarfed and malformed, and lose vigor. Symtoms include stunted, wilted and discolored plants, leaves curl downward and pucker. Heavily infested plants turn	Use regular monitoring, yellow sticky traps. Use resistant varieties. Many predators and parasitoids attack aphids, especially in	No treatment threshold. To control aphids:

Table 23. Papaya			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	brown and die from the top down. Aphids produce sticky honeydew on which grows black sooty mold, blocking sunlight and photosynthesis.	orchards that are not sprayed or sprayed with less toxic materials. Remove infested culls and weedy species around orchard. Prune away parts heavily infested with aphids.	neem seed extract garlic extract chili extract
Papaya Ringspot Virus (PRSV) transmitted by aphids	Early symptoms include yellow mottling of and vein-clearing of leaves. As the disease progresses, the lobes of the leaves become distorted and leaf size is greatly reduced. Fruit symptoms consist of dark circles or C-shaped markings on the fruit peel. Leads to yellowing of the crown of the papaya.	Use resistant varieties. Control aphid vectors. Disinfect cultivation equipment regularly.	No treatment threshold. see above, aphid control
Damping off/stem rot (*Pythium aphanidermatum*)	Soil-borne pathogen that usually begins as a root rot. It survives as oospores that germinate and attack root hairs and root tips of seedlings, causing rotting of the root systems. The seed may fail to germinate because it rots in the ground or the seedling may wilt	Use seed and transplant treatments before putting them in the field. Provide good soil drainage and good air circulation	No treatment threshold. neem seed extract

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	before aboveground lesions are seen. Conditions for the development of this disease are poor soil aeration with high moisture, high temperature, high humidity, high levels of nitrogen fertilizer, and closely sown seed.	among plants. Plant when temperatures are favorable for fast plant growth. Avoid application of excessive amounts of nitrate in nitrogen fertilizers. Practice crop rotation.	méfenoxam (Apron Star 42 WS)
Charcoal and post-harvest rot (*Macrophomina phaseolina*)	Charcoal rot, a soil-borne pathogen with a wide host range, produces black microsclerotia that enable it to survive adverse environmental conditions. It attacks plant stems, cotyledons and roots, leading to plant death. Tissues appear water-soaked, followed by brown, then black as microsclerotia are produced. In the absence of hosts, the microsclerotia survive in the soil for 2–15 years, depending on environmental conditions.	Use resistant hybrids. Eliminate low areas in the orchard and improve drainage. Good water management to avoid stressing plants, particularly as the crop approaches the flowering stage. Do not over-fertilize, especially with nitrogen. Remove and destroy crop	No treatment threshold. No fungicides are recommended.

Table 23. Papaya			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		residues at the end of the season.	
Anthracnose and dieback (*Colletotrichum gloeosporioides, Glomerella cingulata*)	Disease leads to dark, sunken, circular necrotic tissue, with circles of pink eruptions of spores radiating out from the center. The disease is disseminated by wind and rain.	Use resistant cultivars. Dip propagation material in hot water. Do not over-crowd plants.	No treatment threshold. chlorothalonil (Jumper 75 WG) mancozeb (Dithane M45, Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP) azoxystrobin (Azox, Ortiva 250 SC, Ortiva Top) tébuconazole + trifloxystrobin (Nativo 300 SC)
Fruit and post-harvest rot (*Rhizopus, oryzae stolonifer*)	Infection leads to soft and watery rot that quickly collapses the entire fruit but leaves the cuticle intact. The fungus can grow out through any break in the cuticle and spread rapidly to adjacent fruits, often destroying	Regularly and quickly remove and destroy rotting fruit in packing plants.	No treatment threshold. mancozeb (Dithane M45,

Table 23. Papaya			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
	the entire contents of a box of fruits within a few days. The infected fruit is often covered by coarse, gray, hairy mycelia that form a mass of black sporangia at their tips. The affected fruit becomes quickly colonized by yeasts and bacteria and emanates a sour odor. A major constraint that limits production in the Sahel.	Chlorinate wash water. Disinfect processing and packaging equipment. Minimize wounds from the time of harvest until the time to consumer.	Manco 80 WP, Coga 80 WP, Manga Plus, Ivory 80 WP) azoxystrobin (Azox, Ortiva 250 SC, Ortiva Top)

Apple of the Sahel

Apple of the Sahel, *Ziziphus mauritiana*, a medium-size tree is believed to have originated in Indo-Malaysian region of South-East Asia. The fruit is yellow-orange and oblong soft juicy drupe with a thin glossy skin. The flesh is white and crisp. The fruit is eaten raw, pickled, dried or used in beverages. It is quite nutritious and rich in Vitamin C.

Table 24. Apple of the Sahel			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Soil pest: Termites (*Coptotermes spp.*) (termites)	Termites are generally white to cream-colored, 3-7 mm, with red-brown heads. They live in a protected	Use tolerant varieties.	No treatment threshold

Table 24. Apple of the Sahel			
	nest or mound and travel to crops through dried mud and saliva tubes in the soil and up trees, stalks and other vertical objects structures. The tubes protect termites from dessication. Termites feed on tree bark, often girdling twigs, branches and smaller trees, disrupting movement of nutrients and water, killing parts or the entire tree. A major constraint that limits production in the Sahel.	Locate and destroy termite nests and mounds near crop fields. Use healthy uninfested cuttings and seedlings. Use an organic and non-organic fertilizer combination to favor the growth of the seedlings. Continually monitor trees for mud tubes, and manually remove.	No insecticides are recommended
Fruit flies (*Carpomya incompleta*) (Mouche des fruits)	Distorted young fruits with brown egg-laying spots that soften and sink, with maggots feeding inside, ruining the gruit for market. A major constraint that limits production in the Sahel.	Use resistant grafted planting materials. Harvest fruit as it matures. Sanitation: Prune trees to open the canopy. Clean up and destroy dropped infested mangoes.	No treatment threshold neem seed extract garlic extract malathion (Fyfanon 880 EC) spinosad (Laser 480 EC)

Fodders

Dolique bean

Dolique bean, *Vigna unguiculata subsp. sesquipedalis*, is grown for use as an animal fodder for livestock food during the dry season.

Table 25. Dolique bean			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
Root Knot Nematodes (*Meloidogyne spp.*) (Nématode à galles)	Microscopic nematodes feed within plant root zones on newly developed roots. Root-knot nematodes enter and cause galls of up to 3 cm in diameter to appear on roots as quickly as a month after planting. Nematode feeding interferes with the flow of water and nutrients to the plant. Infected plants are prone to wilt in hot weather, and respond poorly to fertilizer; young plants may experience reduced vigor, slow growth, and stunting.	Use resistant varieties. Do weed management in field. Use crop rotation, fallow, and intercropping, mixed cropping or cover cropping with non-host crops. Field solarization (a transparent polyethylene film is laid over moist soil for a 6-to-12-week period to heat). Flood the plot. Avoid growing on a known infected plot. Use 2 kilos of compost per plant to enhance soil organic matter and microbial composition. Plant Marigold (pyreuthrum flower) and plow under the soil 2 months later. Use Tithonia diversifolia as organic compost. Do “biofumigation” of the soil by growing,	No reasonable treatment threshold. fluopyram (Velum Prime 400 SC)

Table 25. Dolique bean			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**
		grinding/macerating and plowing under crucifers/mustards, and covering the soil with plastic, if available, until just before planting. Rotting crucifers produce toxic gasses that kill nematodes, and covering with plastic increases efficacy. Do not allow irrigation water to flow from an infested field to other fields without impounding. Prevent animal grazing and movement from infested to uninfested fields. Sanitation: Remove or compost crop residues after harvest, let them dry out before destruction. Do crop rotation to non-host or nematode-suppressing crops like pyrethrum flower, common vetch, rapeseed, Chrysanthemum, velvet bean, partridge pea, castor bean, or sesame.	

Table 25. Dolique bean			
Primary Pests, Diseases, and Weeds	**Description of each pest, disease or weed and damage it causes**	**Preventive IPM tools and tactics to employ before pesticides are used**	**Treatment thresholds, pesticide AIs and (Trade Names)**

ANNEX 2 GUIDELINES FOR PMPS FOR REGIS PROJECTS TARGET CROPS, BENEFICIARIES AND ELEMENTS OF AN IPM PROGRAM

What is a PMP[14]?

Pest Management Plans or Guides provide field crop, livestock/dairy production or project decision-makers – farmers and farm managers – with best production practices recommendations, usually adapted by region, crop phenology and seasons. The aims of PMPs are to reduce the risks to production from pests by using a combination of best practices, including IPM, Integrated Vector Management (IVM) and Integrated Weed Management (IWM), that maximize crop or livestock/dairy health, and thus resilience to or tolerance of pests, and without an over-reliance on pesticides needed when best practices are not followed. Thus, prevention of pests plays a strongly pivotal role in the PMP, followed closely by management of pests when prevention alone is not adequate for the level of control needed or desired.

Who are the PMP's intended audiences and users?

- Farm land preparation and crop production decision-makers
- Farmers
- Farm managers

Why is a PMP being done?

PMP Objectives:

- Prevent or reduce pest damage risk to agricultural production or health
- Protect the health of farmers, farm family members, laborers and community members from pesticide risks
- Maintain economically sound practices
- Reduce environmental pollution and degradation risks
- Enhance the overall quality and quantity of biodiversity on the sustainable farm work environment

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14 PMPs or Year-Round (seasonal) IPM Programs are state of the art in many developed countries, and they help institutionalize IPM in planning and practice. PMPs provide agriculture managers and farmers with a tool to predict and prevent many crop pests of each crop throughout a season. See examples of PMPs at HTTP://WWW.IPM.UCDAVIS.EDU/PMG/CROPS-AGRICULTURE.HTML, green check marks show "Year-Round IPM Programs".

- Respond to foreign market demand for the use of agriculture sector best management practice standards, also called GCPs/GAPs which include IPM measures, to achieve farm and produce certification

- Comply with local, regional, donor and international laws, conventions, and regulations

Organization of the PMP

The following pieces of crop- or livestock/dairy-specific background information are used to build a PMP base

- General information on the crop/livestock/dairy/sector

- Crop/livestock/dairy common/species names:

- Crop/livestock/dairy developmental stages:

- Production regions and how they differ by soil type, pH, fertility, etc

- Overall concerns and priorities for crop/livestock/dairy production

- Crop/livestock/dairy cultural best practices

- Crop/livestock/dairy GCPs/GAPs including some IPM (see PERSUAP section on GAPS and IPM) recommendations

Individual Pest Prevention and Management Sections for each of the following pest types:

- Invertebrate (Insects, Mites, Slugs/Snails, Nematodes)

- Diseases (Fungi, Bacteria, Viruses, Other)

- Weeds (annual grasses, broadleaves, perennial grasses, broadleaves, sedges, others)

- Vertebrates (birds, rodents, other)

For each pest type, first, identify overall priorities for pest prevention and management in the target crop or livestock/dairy.

Next, identify individual pest species noting the type of damage incurred; part of plant damaged: roots/rhizomes/tubers, stems/stalks, leaves, florescence, or seeds (field or stored); or if livestock/dairy, part of animal affected.

To best understand how to manage a pest, one needs to understand how, where, when and on what parts of the plant or animal the pest feeds. For field pests and stored grain/food pests, many PMPs are designed and outlined as follows, *for each major species of pest (insects, mites, slugs/snails, nematodes)*:

- Photographs of each pest, life stages
- Photographs of plant or livestock/dairy damage
- Description of the pest, life cycle and survival strategies
- Description of damage symptoms
- Best Prevention Practices
    - Use any and all of the above GCPs/GAPs including IPM
    - Country or region-specific information
- Best Management Practices
    - Focus on prevention (above)
    - Country or region-specific information

Information on PMP-recommended pesticides:

Information needed for each pesticide referenced in the above PMP, by pest (so the farmer/farm manager has the information at their fingertips and do not need to refer to other documents and tables to find it):

Pesticide essential information needed

- Active Ingredient (AI) name
- Product Trade names (with EPA and WHO Acute Toxicity Classifications in parenthesis)
- Amounts to use per hectare
- Price
- Pre-Harvest Interval (PHI)
- Special comments on best application methods and frequency
- Any resistance management strategies needed
- Pesticide application record sheet
- Guidelines for reducing spray drift
- REI: field safe re-entry period after spraying
- Maximum residue levels (MRL) permitted by markets

- Pesticide precautions with use including
- Reading the label
- Legal responsibilities and permitted registration uses
- Permit requirements for possession and use
- Recommended and obligated use of PPE and best practices
- First aid and antidotes
- Transportation best practices
- Storage best practices
- Safe use best practices
- Container disposal best practices
- Leftover pesticide disposal best practices
- Protection of non-pest animals, plants, endangered species and water body quality
- Protect natural enemies & honeybees: http://www.ipm.ucdavis.edu/PMG/r584310111.html
- Posting signage in treated fields
- Some chemicals not permitted on processed crops
- Potential for phytotoxicity (crop injury) on some crops
- Documentation and record-keeping on farms

Information needed on Natural Enemies of Pests:

Common Names of Predators and Parasitoids effective against above pests: For a list of common natural enemies of crop pests, see http://www.ipm.ucdavis.edu/PMG/NE/index.html. Genera will likely be the same around the world, with different species in different continents, filling similar niches.

Additional Information Needed:

Will there be an IPM Coordinator, an IPM Advisory Committee, Education and Licensing for Applicators, Currency and Approval of the PMP?

ANNEX 3: ELEMENTS OF IPM PROGRAM

Although farmers are likely using numerous IPM tactics, without really calling them that, IPM philosophy or planning is not generally an active part of crop production in most emerging market countries; thus, a basic understanding of the steps or elements needed in an IPM program are addressed below, as formulated by Food and Agriculture Organization (FAO) of the United Nations (UN)[15].

Step 1: Learn and value farmers' indigenous IPM tactics.

Most farmers are already using their own forms of GAPs and IPM, many of which are novel, self-created, adapted for local conditions, and many of which work well. These local tools and tactics need to be well understood and considered when making PMPs. Accurate assessments of these farmers' GAP and IPM technologies, as well as an understanding of actual losses due to different constraints in farmers' fields are required before designing a crop production and pest management program.

Step 2: Identify key pests for each target crop.

Although perhaps up to ten species of pests may impact a crop and yields at different plant growth stages, generally only two or three are considered serious enough to spend money controlling. Farmers should be encouraged to monitor their population size, their life cycle, the kind of damage they cause and actual losses. Note that crop loss figures based on farmers' perceptions of damage and loss are often overestimated.

Step 3: Evaluate all management options.

Use of best management practices, preventive measures, and "organic" options to control pest impacts may eliminate the need for synthetic pesticides.

Step 4: Choose IPM methods; identify Needs, and Establish Priorities.

Continue dialog with project field staff, ministry extension staff and farmers when choosing methods to be used. Consider the feasibility of attractive methods, including the availability of resources needed, farmers' perceptions of pest problems, their abilities to identify pests, their predators, diseases and parasitoids, and to act upon their observations.

Step 5: Do effective activities and training to promote IPM.

Next, identify strategies and mechanisms for fostering the transfer of the needed IPM technology under various project and institutional arrangements, mechanisms, and funding levels. Define

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15http://www.fao.org/docrep/006/ad487e/ad487e00.htm; http://www.fao.org/docrep/006/ad487e/ad487e02.htm; http://en.wikipedia.org/wiki/Farmer_Field_School; http://www.ipm.ucdavis.edu/PMG/crops-agriculture.html what is available for immediate transfer and what may require more adaptation and validation research. Set up an initial planning workshop (with a COP-supported and signed Action Plan) to help define and orient implementation activities, and begin to assign individual responsibilities.

Learning-by-doing/discovery training programs

The adoption of new techniques by small-, medium- and large-holder farmers occurs most readily when program participants acquire knowledge and skills through personal experience, observation, analysis, experimentation, decision-making and practice. Trained instructors or extension agents conduct frequent (usually weekly) sessions for 10–20 farmers during the cropping season in farmers' fields.

Smallholder support and discussion groups

Weekly meetings of smallholders, held during the cropping season, to discuss pest and related problems are useful for sharing the success of various control methods. However, maintaining attendance is difficult except when there is a clear financial incentive (e.g., credit, advance knowledge of nearby infestations for early action leading to yield improvement).

Educational material

In many countries, basic written and photographic guides to pest identification and crop-specific management techniques are unavailable or out of date. Videos featuring graphic pictures of the effects of acute and chronic pesticide exposure, and interviews with poisoning victims can be particularly effective.

Youth education

Promoting and improving the quality of programs on IPM and the risks of synthetic pesticides has been effective at technical schools for rural youth. In addition to becoming future farmers, these students can bring informed views back to their communities.

Food market incentives (especially important in the last decade)

Promoting Organic, GlobalGAP, BRC, Fair Trade or other certification for access to the lucrative and rapidly growing Standards and Certification (S&C) systems-driven international and regional food markets can be, and is, a strong incentive to adopt IPM.

Step 6: Partner successfully with other IPM implementers.

The following design steps are considered essential.

Articulate the partnership's vision of IPM

Organizations may forge partnerships based on a common commitment to "IPM" – only to discover too late that that their visions of IPM differ considerably. It is therefore highly important that partners articulate a common, detailed vision of IPM, centered on the crops and conditions the project will encounter.

Confirm partner institutions' commitment

The extent of commitment to IPM integration into project, design, and thus implementation depends strongly upon the following key variables:

IPM program integration into larger project

The IPM program is likely to be part of a larger "sustainable agriculture" project. The IPM program must fit into a partner's overall goals. The extent of this integration should be clearly expressed in the proposed annual work plan.

Cost sharing.

The extent of funds (or in-kind resources) is a good measure of a genuine partner commitment.

Participation of key IPM personnel

Organizations should have staff with expertise in IPM. In strong partnerships, these staff members are actively involved in the partnership.

Step 7: Monitor the fields regularly.

At minimum twice a week, farmers should monitor their fields for pests, as some pest populations increase rapidly and unexpectedly; this increase is usually related closely to the stage of crop growth and weather conditions, but it is difficult to predict the severity of pest problems in advance.

Step 8: Select an appropriate blend of IPM tools.

A good IPM program draws from and integrates a variety of pest management techniques, like those presented in the above list. Flexibility to fit local needs is a key variable. Pesticides should be used only if no practical, effective, and economic non-chemical control methods are available. Once the pesticide has been carefully chosen for the pest, crop, and environment, it should be applied only to keep the pest population low, not necessarily eliminate it.

Step 9: Develop education, training, and demonstration programs for extension workers.

Implementation of IPM depends heavily on education, training, and demonstration to help farmers and extension workers develop and evaluate the IPM methods. Hands-on training conducted in farmers' fields (as opposed to a classroom) is a must. Special training for extension workers and educational programs for government officials and the public are also important.

Step 10: Monitoring, Record-Keeping and Evaluation (M&E).

Develop data collection forms and checklists, collect baseline GAP/IPM data at the beginning of the project, and set targets.

For the use and maintenance of Good Agriculture Practices (that include safe pesticide storage, use and disposal), maintain farm or project files of: farmer and farm employee training records certification; farm soil, water, biodiversity, cropping and pesticide use maps; pesticide purchase and stock records; price increases or decreases, chemical application instructions including target pest, type of chemical applied, dosage, time of spray, rates at which pesticides were applied, harvest interval days, application machinery, PPE required and used, and any special instructions on mixing, exposure to children or dangers.

Further, for project staff, beneficiaries, produce processing facilities, food warehouses, seed multipliers, or farmers that store seed or food and deal with stored seed and food pests, there are warehouse BMPs and monitoring reports that incorporate some IPM tactics. These monitoring forms track, by location or warehouse, use of pallets, stacking, general hygiene and sanitation, damaged packages, actual infestations or signs of rodents, molds, insects, drainage, locks and security measures, use of IPM tactics including least toxic chemicals and strict BMPs, including restricted access, for use of common but hazardous fumigants like aluminum phosphide.

ANNEX 4: ANALYSES OF ACTIVE INGREDIENTS IN PESTICIDES REGISTERED BY INSAH

Annex 4 below compiles the AIs in pesticides registered by INSAH and botanical extracts made artisanally, in small batches and by smallholder farmers, for use in West African countries, as evaluated and approved by this PERSUAP. Pesticide AIs rejected by this PERSUAP analysis are in Annex 12. Project field technical decision-makers—especially those who interface at the field level with beneficiary farmers—are encouraged to look at the label of potential pesticide choices to determine the recommended uses, dosages and precautions. For AIs contained in them, use this Annex as a quick reference guide to human and environmental acute and chronic attributes and issues with each chemical.

The pesticide attributes include pesticide class (to manage resistance by rotating chemicals from different classes), EPA registration and RUP status (to comply with Regulation 216) and acute toxicity (judged by this document to be safe, or not, for smallholder farmers—most Class I chemicals are not considered safe for smallholder farmers to use). Annex 4 also presents chronic health issues, water pollution potential, and potential toxicities to important non-target organisms like fish, honeybee pollinators, birds and several aquatic organisms.

Further, Annex 4 contains basic pieces of human safety and environmental data needed for the various analyses required throughout the PER 12-factor analysis; as detailed in the matrix header. Thus, this PERSUAP provides useful tools for evaluating and choosing among IPM options, including natural and synthetic pesticides, while adhering to 22 CFR 216.

Key to Annex 4 matrix, below:

RUP: Few = one or two products; Some = a third of products; Most/All = most or all products containing the AI are labeled RUP by EPA

WHO Acute Toxicity Classes: Ia = Extremely Hazardous; Ib = Highly Hazardous;

II = Moderately Hazardous; III = Slightly Hazardous; U = Unlikely to present acute hazard in normal use; NL = not listed

EPA Acute Toxicity Classes: I = Extremely Toxic; II = Highly Toxic; III = Moderately Toxic;

IV = Slightly Toxic

Chronic Human Toxicity: KC = Known Carcinogen; PC = Possible Carcinogen; LC = Likely Carcinogen; ED = Potential Endocrine Disruptor; RD = Potential Reproductive & Development Toxin; P = Parkinson's Disease Risk; NL = not listed

Ecotoxicity: NAT = Not Acutely Toxic; PNT = Practically Not Toxic; ST = Slightly Toxic; MT = Moderately Toxic; HT = Highly Toxic; VHT = Very Highly Toxic

Table 26. Fungicide AIs in INSAH-Registered Products

Fungicide Active Ingredients proposed for control of crop diseases and thus proposed for Reg 216 analysis	Reg 216, Factor I Availability of Other Pesticide Options: AI chemical classes for rotation to avoid development of resistance, and reduction of effectiveness (Factor F)	Reg 216, Factor A: Is AI EPA Registered?	Reg 216, Factor A: Any Restricted Use Pesticides with this AI?	Reg 216 Factor E: WHO Acute Toxicity Class	Reg 216 Factor E: EPA Acute Toxicity Classes	Reg 216 Factor E: Chronic Toxicity	Reg 216 Factors G & H (Non-target ecosystem, Hydrology): Groundwater contaminant	Reg 216 Factors E & G: Ecotoxicity, Non-target Impacts								
								fish	bees	birds	amphibians	worms	Mollusks	Crustaceans	Aquatic Insects	Plankton
Aspergillus flavus	microbial	yes	no	NL	III	NL	no data									
azoxystrobin	strobin	yes	no	U	II, III	NL	potenti al	MT	MT	MT		MT		MT		VHT
chlorothalonil	chloronitrile	yes	few	U	I, II, III	PC	potenti al	VHT			HT		ST	VHT	MT	MT
difenoconazole	azole	yes	no	II	III	PC	no data	MT	MT	ST		MT		MT		HT
mancozeb	dithiocarbamate	yes	no	U	III	PC, ED, RD	no data	MT	MT	ST	HT					NAT
metalaxyl	phenylamide	yes	no	III	II, III	NL	potenti al	ST	PNT	PNT						ST

mefenoxam	phenylamide	yes	no	II	II, III	NL	no data	MT	NAT	MT		MT		MT		
tebuconazole	azole	yes	no	II	II, III	PC	potenti al	MT	MT	MT		MT		MT	MT	HT
thiram	(dithio) carbamate	yes	no	II	I,II,III	ED, RD	no data	HT	NAT	PNT	VHT	HT		NAT	HT	HT
trifloxystrobin	strobin	yes	no	U	II,III	NL	no data	ST	ST	MT		MT				

Table 27. Approved Herbicide AIs in INSAH-Registered Products

								Reg 216 Factors E & G: Ecotoxicity, Non-target Impacts								
Herbicide Active Ingredients proposed for control of crop diseases and thus proposed for Reg 216 analysis	**Reg 216, Factor I Availability of Other Pesticide Options: AI chemical classes for rotation to avoid development of resistance, and reduction of effectiveness (Factor F)**	**Reg 216, Factor A: Is AI EPA Registered?**	**Reg 216, Factor A: Any Restricted Use Pesticides with this AI?**	**Reg 216 Factor E: WHO Acute Toxicity Class**	**Reg 216 Factor E: EPA Acute Toxicity Classes**	**Reg 216 Factor E: Chronic Toxicity**	**Reg 216 Factors G & H (Non-target ecosystem, Hydrology): Groundwater contaminant**	**fish**	**bees**	**birds**	**amphibians**	**worms**	**Mollusks**	**Crustaceans**	**Aquatic Insects**	**Plankton**
2,4-dichlorophenoxyacetic acid (2,4-D)	chlorophenoxy acid	yes	no	II	I,II,III	PC, ED	potential	ST	HT	MT	ST	NAT	NAT	NAT	ST	ST
2, 4 D dimethylamine (salt)	chlorophenoxy acid	yes	no	NL	I,II,III	PC	potential	NAT			NAT		ST	NAT		NAT
clethodim	cyclohexenone	yes	no	NL	II, III	NL	potential	MT	MT	MT		MT		MT		
clomazone	isoxazolidinone	yes	no	II	III	NL	no data	MT	MT	NAT		MT		MT		HT
glyphosate	phosphonoglycine	yes	no	III	I,II, III	NL	potential	ST	ST	NAT		PNT		MT		ST

nicosulfuron	sulfonylurea	yes	no	U	III	NL	potenti al	MT	MT	MT		MT		MT		
oxadiazon	oxidiazole	yes	no	U	II, III	**KC**, RD	no data	MT	MT	ST	MT	MT		ST		HT
oxyfluorfen(e)	diphehyl ether	yes	no	U	II, III	PC	no data	HT	PNT	PNT			HT		HT	HT
pendimethalin	dinitroanaline	yes	no	II	III, IV	PC, ED	no data	MT	NAT	ST				MT	MT	
rimsulfuron	sulfonylurea	yes	no	U	II,III	NL	potenti al	NAT	MT	NAT		MT				NAT

TABLE 28. APPROVED INSECTICIDE, MITICIDE AND NEMATICIDE AIS IN INSAH-REGISTERED PRODUCTS

Insecticide Active Ingredients proposed for control of crop diseases and thus proposed for Reg 216 analysis	Reg 216, Factor I Availability of Other Pesticide Options: AI chemical classes for rotation to avoid development of resistance, and reduction of effectiveness (Factor F)	Reg 216, Factor A: Is AI EPA Registered?	Reg 216, Factor A: Any Restricted Use Pesticides	Reg 216 Factor E: WHO Acute Toxicity Class	Reg 216 Factor E: EPA Acute Toxicity Classes	Reg 216 Factor E: Chronic Toxicity	Reg 216 Factors G & H (Non-target ecosystem, Hydrology/ Groundwater	Reg 216 Factors E & G: Ecotoxicity, Non-target Impacts								
								fish	bees	birds	amphibians	worms	Mollusks	Crustaceans	Aquatic Insects	Plankton
abamectin (insects too)[16]	microbial extract	yes	**some**	NL	II, III	ED, RD	no data	ST	HT	PNT		MT		HT	VHT	VHT
acetamiprid	neonicotinoid	yes	no	NL	III	NL	potential	NAT	MT	HT				NAT		
Bacillus thuringiensis/BT (Kurstaki)	microbial	yes	no	III	III	NL	no data	MT	PNT	NAT	NAT		ST	ST		
chlorpyrifos-methyl	organophosphate	yes	no	III	I, III	NL	no data	MT	HT	MT	MT			VHT	VHT	MT
deltamethrin (storage pests only)	synthetic pyrethroid	yes	**some**	II	**I**, II, III	ED	no data	HT	MT		VHT		NAT		VHT	VHT
dimethoate	organophosphate	yes	few	II	II,III	PC, ED, RD	potential	ST	VHT	VHT	HT	MT	VHT	HT	VHT	MT
fluopyram (nematodes, fungi too)	benzimide	yes	no	III	III	PC	no data	MT	MT	MT		MT		MT		
imidacloprid	neonicotinoid	yes	no	II	II, III	NL	potential	NAT		MT					VHT	
kaolin clay (aluminum silicate)	inorganic	yes	no	NL	III	NL	no data									

[16] Abamectin is active primarily against mites, but some insects too. Other AIs listed here also have such dual activity as indicated by the title.

malathion	organophosphate	yes	no	III	II,III	PC, ED	potential	MT	HT	MT	HT	ST	VHT	MT	VHT	HT
permethrin	synthetic pyrethroid	yes	**some**	II	I,II,III	PC, ED	no data	VHT	VHT	PNT	ST	ST	ST	VHT	MT	MT
pyrimiphos-methyl (storage pests)	organophosphate	yes	no	II	**I**,III	NL	no data	MT	HT	MT		MT			VHT	VHT
spinosad (mites too)	microbial	yes	no	III	III,IV	NL	no data	MT	HT	PNT		ST			HT	MT
Tagetes African Marigold oil	botanical	yes	no	NL	IV	NL	no data									
thiamethoxam	neonicotinoid	yes	**no**	NL	III	PC	no data	PNT	HT	PNT		PNT	PNT	PNT	PNT	
thyme oil	botanical	yes	no	NL	III,IV	NL	no data	ST								

Table 29. Approved REGIS Artisanal Biologicals/Biostimulants

orange skin extract	botanical	yes	no	NL	III	NL	no data	MT						MT	ST	
garlic extract	botanical	yes	no	NL	III	NL	no data	VHT	HT	HT	MT	MT	MT	VHT	VHT	ST
onion extract	botanical		no	NL	NL	NL	no data									
neem tree seed extract	botanical	yes	no	NL	III	ED	no data	ST	NAT	NAT	MT				MT	
chili pepper extract	botanical	yes	no	NL	III	NL	no data							ST		

Table 30. Approved Rodenticide AIs in INSAH-Registered Products

Reg 216 Factors E & G: Ecotoxicity, Non-target Impacts

Rodenticide Ingredients proposed for control of crop diseases and thus proposed for Reg 216 analysis	Reg 216, Factor I Availability of Other Pesticide Options: AI chemical classes for rotation to avoid development of resistance, and reduction of effectiveness (Factor F)	Reg 216, Factor A: Is AI EPA Registered?	Reg 216, Factor A: Any Restricted Use Pesticides with this AI?	Reg 216 Factor E: WHO Acute Toxicity Class	Reg 216 Factor E: EPA Acute Toxicity Classes	Reg 216 Factor E: Chronic Toxicity	Reg 216 Factors G & H (Non-target ecosystem, Hydrology): Groundwater contaminant	fish	bees	birds	amphibians	worms	Mollusks	Crustaceans	Aquatic Insects	Plankton
brodifacoum	coumarin	yes	no	Ia	III	none	no data	MT				MT				

ANNEX 5: GUIDANCE ON SCREENING PESTICIDES FOR INCREASED LIKELIHOOD OF QUALITY

The following are some general best practices for buying pesticides.

Do not buy pesticides if the:

1. bottle has been opened.

2. label shows that it is expired.

3. pesticide is in a quantity much larger than what is needed for one season.

4. label is in a language that is not understood.

5. label is missing, damaged or unreadable.

6. bottle is damaged and/or leaking.

7. manufacturer and/or distributor name and contact information are not on the label.

8. pesticide shop smells of pesticides.

9. floor of the pesticide shop has spilled pesticides on it.

10. label has no safety and PPE information on it.

11. label has no poison control information on it.

12. label does not clearly identify the active ingredient names.

13. product has not been registered by the local MOAs.

Be wary of pesticides manufactured in China, or from Chinese companies.

As possible, and if available, choose pesticides from well-known international companies such as:

- AMVAC,
- Arysta Lifescience,
- Bayer,
- BASF,
- Chemtura,
- Crop Production Services,
- Dow Agrosciences,
- Drexel,
- DuPont,

- FMC,
- Gowan,
- HELM Agro,
- Makhteshim-Aghan,
- Monsanto,
- Nufarm,
- Sumitomo,
- Syngenta,
- United Phosphorous,
- Valent

Carefully consider the label:

- it must be securely attached to the package;
- information on it should be clearly printed and be in one or more national languages;
- it should indicate the name of the manufacturer's supplier and its addressee, the active ingredient, product name, batch number, weight or volume, date of manufacture and expiry date;
- means of application (application rate, species on which it works, method, decontamination methods, safety measures and first aid) should be clearly written;
- grammar errors on the label are a clear sign of a fake product.
- ▸ Pay attention to the fact that the agricultural chemicals are never packed in medical containers.
- ▸ Pay attention to the (underestimated) price of pesticides.

Some additional guidance is provided at the following websites:

http://www-pub.iaea.org/MTCD/Publications/PDF/te_1612_web.pdf

http://www.npic.orst.edu/ingred/ptype/illegal/index.html

https://www.epa.gov/safepestcontrol/avoid-illegal-household-pesticide-products

http://edis.ifas.ufl.edu/pi210

http://www.fao.org/fileadmin/templates/agphome/documents/Pests_Pesticides/Code/Report.pdf

http://www.fao.org/fileadmin/templates/agphome/documents/Pests_Pesticides/Code/JMPM_2010_report.pdf

http://www.osce.org/secretariat/192516?download=true http://npic.orst.edu/ingred/manuf.htm

https://www.uky.edu/Ag/Horticulture/masabni/xreflist/pesticidecompaniesnames.htm

ANNEX 6: TRAINING TOPICS AND SAFE PESTICIDE USE WEB RESOURCES

MANDATORY ELEMENTS OF PESTICIDE SAFE USE TRAINING

Pesticide safe use training must address the following minimum elements.

- Definition of pesticides.
- Choice of high quality generic or patent-protected pesticides from reputable companies
- Avoidance of fake, diluted/adultered or counterfeit pesticide products
- Pesticide risks and the understanding that pesticides are bio-poisons.
- Concepts of AIs vs. formulated products.
- Classes of pesticides and the concept that specific pesticides are effective against only certain classes of organisms.
- Concept of proper application rates and the concept of pesticide resistance and techniques for preventing resistance.
- Concept that pesticides have specific organisms against which they are effective.
- Survey of the core elements of safe pesticide use: IPM, safe purchase, transport, storage, mixing, application, re-entry and pre-harvest intervals, and clean-up and disposal, including specific treatment of PPE.
- Pesticide first aid and spill response.
- Interpretation of pesticide labels, particularly to understand PPE requirements and other precautions, dosage rates, and to identify AIs and expiration dates.
- Proper sprayer operation and maintenance.
- Precautions before, during and after spraying.
- The choice of appropriate times for spraying

The following sections provide specific content notes on some of these topics.

6.1 INTEGRATED PEST MANAGEMENT

IPM is an integral part of safe pesticide use and supporting the use of pesticides only within an IPM framework is a core requirement of this PERSUAP. Therefore, pesticide safe use training must build an understanding of IPM fundamentals.

The heart of IPM is an understanding of the relationship between pest injury, damage, yield loss, and economic loss. IPM was developed within the discipline of economic entomology. Farmers who are not trained in IPM may spray a crop upon seeing a single insect in a field or a few brown spots of a disease on a leaf. Pesticides are expensive and should only be used as a last resort and only when economically justified.

Threshold determination. Extension workers and farmers first need to understand the relationship between increasing injury levels and crop yield of each pest which is known as the damage function. A small amount of injury, in fact, can cause yield gain called overcompensation. In most cases, significant yield loss does not occur until a certain pest density occurs in the field because the crop can compensate for this level of damage. Then there is normally a linear decline in yield with increasing pest density. From this relationship, the economic injury level, economic threshold, or action threshold can be defined in the case of insect pests. Other methods to assess the threat of weeds and crop diseases will need to be developed based on field experience. Certain guidelines can be developed based on experience in neighboring countries.

IPM involves several tiers of integration. First there is the integration between control methods which must be harmonious. A non-harmonious example is the negative effect of pesticides on biocontrol agents. Biocontrol, which is the action of natural enemies against the pest, is free to the farmer so it behooves him not to upset this delicate balance unless necessary. The next tier of integration occurs between the different pest control disciplines. When one sprays an insecticide, herbivorous insects feeding on weeds are killed. Some fungicides also kill insect pests. Removing weeds forces army worms to feed on the crop. The third tier is integration with the cropping system and farming system. Crops that are well nourished can tolerate more damage. Many crop husbandry practices also affect pests, either positively or negatively. Application of nitrogen fertilizer is an example. On the one hand, it can stimulate plant diseases, but on the other nitrogen fertilizer can provide strength of the crop to tolerate insect pest damage.

Pests do not occur in isolation; thus, the crop must deal with multiple pests as well as multiple stresses. A crop that is weak from zinc deficiency or water stress cannot tolerate as much pest damage as a healthier crop. In fact, some sucking insect pests explode in abundance on a drought-stressed crop, further exacerbating the problem. The relationship between multiple pests and multiple stresses can be additive (1 + 1 = 2), antagonistic (1 + 1 = 1), or synergistic (1 + 1 = 3). This can occur in terms of yield loss from adding more pests or stresses, or can occur in terms of yield gain when one or more stresses are removed due to an effective curative control effort.

The IPM training will provide examples of the different pest control methods beginning with preventative ones, which start with quarantine and cultural crop husbandry methods based on good agronomic practices. These methods increase the crop's tolerance for pest injury. Many of these methods fall under the rubric of cultural control. Host plant resistance is another good example of prevention. Other pest control methods can be physical (e.g., a fence to keep out animals), mechanical (e.g., using nets), or biological (e.g., parasitoids, predators, pathogens). Biological methods include natural control and man-induced methods, such as purchasing and releasing natural enemies or using selective pesticides.

As a last resort, there is chemical control.

Farmers will need to be trained to recognize pests in the field and to be able to assess their densities, as well as know several methods of control for each. Training manuals with high-quality color photos will be essential in the training process. Government-approved, recommended practices need to be published and updated annually in guides given to extension officers.

Using PPE and clothing needs to be understood for each level of toxicity. This information is summarized below along with other information on the risks and hazards of transport, storage, and disposal of pesticides. Safety practices, such as the importance of pesticides not being stored in the home where children can find them, should also be understood and implemented.

6.2 UNDERSTANDING PESTICIDE RISKS

Many times, non-chemical controls can be used to deal with pests. When deciding to use a pesticide, it is important to understand the risks associated with a specific product or treatment. No matter the treatment method, there is always a degree of risk associated with using a pesticide. Understanding the risk from specific pesticides can help determine whether a given pesticide is appropriate, or help choose between two different products.

Many people believe that some pesticides are "safe," while others are "dangerous." All chemicals, including all pesticides, have the potential to be hazardous. Even products that are considered low in toxicity, natural, or organic can be hazardous if someone or something encounters enough of the substance.

The toxicity of a pesticide, its formulation, and how much a person touches, ingests, inhales, or gets in contact with skin and eyes are all important considerations. The likelihood of experiencing some health effect because of using a product is referred to as the pesticide risk. The pesticide risk depends on which pesticide is used, how much is applied, frequency of application, and who or what has contact with the pesticide. The length of time the exposure occurred and how much of the substance gets on or in the body are important details in understanding the risk.[17]

Occupational exposure often occurs in cases of agricultural workers in fields, people living close to agricultural fields, and people working in the pesticide industry and working in structural pest control. Exposure of the general population occurs primarily through eating food and drinking water contaminated with pesticide residues. Water, soil, and air becomes contaminated from pesticides leaching into the ground, running off into rivers with rain water, or drifting as spray from pesticide applications.

Ecological risk is risk posed by a pesticide to the wildlife and the environment. US EPA looks at ecological risks, including:

- **Wildlife and aquatic organisms:** How could the pesticide affect various animal species?
- **Plant protection:** How could the pesticide affect various plant species?

[17] http://npic.orst.edu/factsheets/WhatsMyRisk.pdf

- **Non-target insect:** How could the pesticide affect insects other than the ones the pesticide is intended to kill?
- **Environmental fate:** What happens to the pesticide in soil, water, and air after being released into the environment?
- **Residue chemistry:** How much pesticide is present in the environment over time after application?
- **Spray drift:** How much could the pesticide drift off-site when sprayed from the air? This helps to determine exposure of non-target organisms.

An adjuvant is any material that is added to a pesticide solution to enhance or modify the performance of the solution. Most pesticides are not flammable, but the solvents or diluents of liquid emulsion concentrates or oil solutions—xylene, kerosene, or other organic solvents—can be flammable and under some conditions explosive. Adjuvant can be inert but it can also significantly increase pesticide toxicity.

6.3 UNDERSTANDING PESTICIDE LABEL AND MATERIAL SAFETY DATA SHEET

The label of a pesticide container must have all the information about risks as well as information needed for safe and effective use. Additional important details about risks of pesticide products and instructions about safe use can be found in the manufacturer's MSDS. Labels and MSDS for some pesticides are available online at http://www.cdms.net and http://www.greenbook.net.

The label on a pesticide container has three main functions:

- To tell the user what pest the product can be used on.
- To tell the user how to handle, use, and store the pesticide safely.
- To tell the user how and when to apply the pesticide for the best effect.

By law, pesticide labels must contain:

- The name of the product.
- Level of toxicity.
- Active ingredients.
- Other ingredients-co-formulates.
- The pests which the product will control.
- The rate of application of the product (how much of it to use).
- The time and method of application.
- Directions for handling the product safely.
- First aid procedures in case of an accident.
- Any special instructions or warnings about its use, transport, storage, or disposal.
- The net contents (weight when packed) of the container.

The pesticide pictogram will provide information about risks and safety measures required including PPE.

All programs must review the MSDS and provide training on reading and understanding the pesticide label prior to using pesticides.

6.4 PESTICIDE SAFETY AND USE OF PROTECTIVE CLOTHING AND EQUIPMENT

Training must address the types of personal protective equipment (PPE), when they should be worn and why.

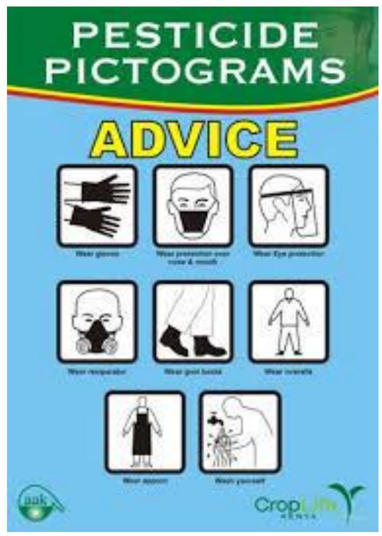
TABLE 31. HANDLER PPE FOR WORKER PROTECTION STANDARD PRODUCTS

ROUTE OF EXPOSURE	TOXICITY CLASSIFICATION BY ROUTE OF EXPOSURE OF END-USE PRODUCT			
	I DANGER	II WARNING	III CAUTION	IV CAUTION
Dermal Toxicity or Skin Irritation Potential[1]/	Coveralls worn over long-sleeved shirt and long pants	Coveralls worn over long-sleeved shirt and long pants	Long-sleeved shirt and long pants	Long-sleeved shirt and long pants
	Socks	Socks	Socks	Socks
	Chemical-resistant footwear	Chemical-resistant footwear	Rubber boots or shoes	Rubber boots or shoes
	Chemical-resistant Gloves[2]	Chemical-resistant Gloves[2]	Chemical-resistant Gloves[2]	No minimum[4]
Inhalation Toxicity	Respiratory protection device[3]	Respiratory protection device[3]	No minimum[4]	No minimum[4]
Eye Irritation Potential	Goggles[5]	Goggles[5]	No minimum[4]	No minimum[4]

[1] If dermal t[1]/Toxicity and skin irritation toxicity categories are different, PPE shall be determined by the more severe toxicity classification of the two. If dermal toxicity or skin irritation is category I or II, refer to the pesticide label/MSDS to determine if additional PPE is required.
[2] Refer to the pesticide label/MSDS to determine the specific type of chemical-resistant glove.

[3] Refer to the pesticide label/MSDS to determine the specific type of respiratory protection.
[4] Although no minimum PPE is required for these toxicity categories and routes of exposure, some specific products may require PPE. Read pesticide label/MSDS.
[5] "Protective eyewear" is used instead of "goggles" and/or "face shield" and/or "shielded safety glasses" and similar terms to describe eye protection. Eye glasses and sunglasses are not sufficient eye protection.

Note: Where necessary, farmers can make their own PPE. For example, a plastic or water repellent apron from the waist to ankle length, can be fashioned from a large piece of plastic purchased in the local market (important if walking through the spray path).



Source: CropLife

6.5 PROPER SPRAY TECHNIQUE: PROTECTING AGAINST PESTICIDE SPRAY DRIFT

Many farmers apply pesticides with a knapsack sprayer, which means that delivery of pesticides is either in front of the person spraying or to the side, not to the back as is the case with tractor-drawn sprayers. Inevitably pesticide drift will be carried by the wind and potentially settle on sensitive ecosystems such as national parks if they are nearby. Herbicides pose the greatest risk for environmental damage, especially when their drift lands on neighbors' crops and kills or severely damages them.

The potential for drift to travel long distances has been shown with highly residual chlorinated hydrocarbon pesticides, such as DDT, which have moved through the atmosphere and been found in measurable quantities at both poles on earth. Pesticides that can be transported to the earth's distant poles are bound tightly to dust particles carried high into the atmosphere and transported by jet streams. Their presence only represents a very small percentage of the drift. Spray drift is a mostly local phenomenon, whereby spray droplets move to areas near the field.

There are several ways in which pesticide drift can be minimized:

Increase spray droplet size. Fog-sized droplets can travel three miles (4.8 km) while coarse droplets typically travel less than 10 feet (3 meters). To increase droplet size, the farmer can reduce spray pressure (e.g., 30 to 50 pounds per square inch [2-3.5 kg/cm^2] with 5 to 20 gallons [19 to 76 liters] of water per acre [.4 ha]), increase nozzle orifice size, use special drift reduction nozzles, and purchase additives that increase spray viscosity.

Distance between nozzle and target. Reduce the distance between the nozzle and the target crop.

Temperature and relative humidity. As pesticides vaporize under high temperature, low relative humidity and/or high temperature will cause more rapid evaporation of spray droplets between the spray nozzle and the target. Evaporation also reduces droplet size, which in turn increases the potential drift of spray droplets. It is best not to spray in the heat of the day to avoid drift problems.

Avoid spraying when the wind speed > 10 mph (16 km/h). As drift occurs as droplets suspended in the air, it is best to minimize applications during windy days. If spraying must be done, however, the farmer should spray away from sensitive areas. Local terrain can influence wind patterns; thus, every applicator should be familiar with local wind patterns and how they affect spray drift.

Do not spray when the air is completely calm or when a temperature inversion exists. When the air is completely still, small spray droplets become suspended in the warm air near the soil surface and will be readily carried aloft and away from susceptible plants by vertical air movement. Temperature inversion occurs when air near the soil surface is cooler than the higher air. Temperature inversions restrict vertical air mixing, which causes small suspended droplets to remain in a concentrated cloud and impact plants two miles or more downwind. This cloud can move in unpredictable directions due to the light, variable winds common during inversions.

Application height. Making applications at the lowest height reduces exposure of droplets to evaporation and wind.

C.6 PESTICIDE TRANSPORT AND STORAGE

Where IPs or beneficiary groups will be transporting pesticides, training must address the fundamentals of safe transport of pesticides. (Some of the largest accidents involving pesticides have occurred during transportation.) Drivers should be trained on how to deal with and contain spills and not to transport pesticides with food. Many of the agro-dealers are small and ship their stock individually in relatively small quantities. Agro-dealers should be sensitized about minimizing potential risks during transportation. Minimum elements of safe transport are:

- Keep pesticides away from passengers, livestock and foodstuffs;
- Do not carry pesticides in driver's compartment;
- Containers must be in good condition;
- Do not transport packages with any leakage; and,
- Transport under cover and protected from rain, and direct sunlight.

Storing pesticides properly protects human and animal health, safeguards wells and surface waters, and prevents unauthorized access to hazardous chemicals. The pesticide label is the best guide to storage requirements for every product. The MSDS provides additional information on normal appearance and odor as well as flash point, fire control recommendations, boiling point, and solubility.

Preventative measures are required in pesticide warehouses to reduce cases of pilferage, exposure through leakages, theft, and expiration of pesticides. Where IPs or beneficiaries, including agro-dealers, will be maintaining pesticide stores, training must address these practices, as per the best management practices for pesticide storage highlighted in Food and Agriculture Organization (FAO) storage manual[18] and summarized below:

- All primary pesticide storage facilities will be double-padlocked and guarded on a 24-hour basis.
- All the storage facilities will be located away from water sources, domestic wells, markets, schools, hospitals, etc. Wastewater from pesticide storage facilities must not be drained directly into public drains but should be pretreated on site.
- Soap and clean water will be available always in all the facilities.
- A trained storekeeper will be hired to manage each facility.
- Pesticides will be stacked as specified in the FAO Storage and Stock Control Manual.
- Inventory management will include recording expiration dates of all pesticides and maintaining a "first-in first-out" stocking system.
- All the warehouses will have at least two exit access routes in case of a fire outbreak.
- A non-water-based fire extinguisher will be available in the storage facilities, and all workers will be trained on how to use this device, and how to respond to fire (see below).
- Warning notices will be placed outside of the store in the local language(s) with skull and crossbones sign to caution against unauthorized entry.

Further, if IP-run pesticide stores exist in an area with fire or emergency services, local first responders must receive training on how to deal with pesticide fires. The smoke from such a fire is highly hazardous and effluent from water spray can do great harm to the environment. If fire fighters use water to put out a fire in a pesticide storage shed, the runoff will be highly toxic.

6.7 FIRST AID

It is important to provide training on recognition of the symptoms of a pesticide poisoning so the victim will receive timely treatment. Contact information of the closest medical facility must be known and available if someone can be possibly poisoned with a pesticide. Quick action could

[18] "Pesticide Storage and Stock Control Manual." Pesticide Storage and Stock Control Manual. Web. 18 Aug. 2015. http://www.fao.org/docrep/v8966e/v8966e00.htm .

save the victim's life. Farmers must be trained to make sure to take the label and if possible the MSDS on the chemical to the hospital. This will enable the medical professionals to treat the victim properly and promptly.

Training must include the basic elements of pesticide first aid, as per the table below. Wherever possible, personnel at local health facilities should participate in/receive such training.

General	Read the first aid instructions on the pesticide label, if possible, and follow them. Do not become exposed to poisoning yourself while you are trying to help. Take the pesticide container (or the label) to the physician.
Poison on skin	Act quickly. Remove contaminated clothing and drench skin with water. Cleanse skin and hair thoroughly with detergent and water. Dry victim and wrap in blanket.
Chemical burn on skin	Wash with large quantities of running water. Remove contaminated clothing. Cover burned area immediately with loose, clean, soft cloth. Do not apply ointments, greases, powders, or other drugs in first aid treatment of burns.
Poison in eye	Wash eye quickly but gently. Hold eyelid open and wash with gentle stream of clean running water. Wash for 15 minutes or more. Do not use chemicals or drugs in the wash water; they may increase the extent of injury.
Inhaled poison	Carry victim to fresh air immediately. Open all doors and windows so no one else will be poisoned. Loosen tight clothing. Apply artificial respiration if breathing has stopped or if the victim’s skin is blue. If victim is in an enclosed area, do not enter without proper protective clothing and

	equipment. If proper protection is not available, call for emergency equipment from your fire department (if available).
Poison in mouth or swallowed	Rinse mouth with plenty of water. Give victim large amounts (up to 1 quart) of milk or water to drink. Induce vomiting only if instructions to do so are on the label.
Procedure for inducing vomiting	Position victim face down or kneeling forward. Do not allow victim to lie on his back, because the vomit could enter the lungs and do additional damage. Put finger or the blunt end of a spoon at the back of victim's throat or give syrup of ipecac. Collect some of the vomit for the physician if you do not know what the poison is. Do not use salt solutions to induce vomiting.
When not to induce vomiting	If the victim is unconscious or is having convulsions. If the victim has swallowed a corrosive poison. A corrosive poison is a strong acid or alkali. It will burn the throat and mouth as severely coming up as it did going down. It may get into the lungs and burn there also. If the victim has swallowed an emulsifiable concentrate or oil solution. Emulsifiable concentrates and oil solutions may cause severe damage to the lungs if inhaled during vomiting.

6.8 PROPER PESTICIDE CONTAINER DISPOSAL

Once pesticides have been used, the empty containers need to be properly disposed of. Training must address proper disposal. This table gives a summary of the best practices for doing so.

Table: Proper Methods to Dispose of Pesticides and their Empty Containers

CONTAINER TYPE	DISPOSAL STATEMENTS
Metal Containers (non-aerosol)	Triple rinse. Then offer for recycling or reconditioning, or puncture and bury.

Paper and Plastic Bags	Completely empty bag into application equipment. Then bury empty bag.
Glass Containers	Triple rinse. Then bury.
Plastic Containers	Triple rinse. Then offer for recycling or reconditioning, or puncture and bury.

6.9 PROPER DISPOSAL OF OBSOLETE AND UNUSED PESTICIDES

Like with many developing countries, farmers in Burkina Faso and Niger rely on informal disposal methods of pesticides which could lead to environmental degradation and negative impacts to human health. According to the FAO, potential methods for disposal of obsolete pesticides include:[19]

- high-temperature incineration;
- chemical treatment; and,
- engineered landfill (for immobilized materials, incinerator ash and slag).

6.10 MONITORING AND DATA RECORD KEEPING

Many Burkinabe and Nigerien small-scale farmers and other beneficiaries, other than those doing export, do not keep records of information on crops grown, production, or activities, materials storage practices, pest attack, pesticides used, whether the pesticides worked well or not, pest resistance development and pre-harvest intervals to reduce pesticide residues. Projects must conduct training programs on monitoring and data record-keeping techniques for pest control and pesticide needs and/or effectiveness.

6.11 EXTENSION MATERIALS PRODUCED BY LOCAL CROP PROTECTION SPECIALISTS DURING THE PERSUAP PROCESS

INTEGRATED PEST MANAGEMENT FOR GARDEN CROPS

[19] FAO, 1996, Guidelines: *Disposal of bulk quantities of obsolete pesticides in developing countries*. The Food and Agriculture Organization of the United Nations (FAO), the United Nations Environment Programme, (UNEP) and the World Health Organization (WHO). Accessed at: http://www.fao.org/fileadmin/user_upload/obsolete_pesticides/docs/w1604e.pdf

Natural products biopesticides, production and use techniques

The use of ‘biological products from vegetable extracts to fight insects or disease vectors is not a new idea. There are several natural products available for killing or repelling insect pests. In this manual we present some of them.

Application of some bio controls for target pests

Product	Thrips	Caterpillars (cabbage, tomato)	Aphids	Chinch
Garlic	+	+	+	+
Neem	+	+	+	+
Hot pepper		+	+	
Tobacco	+	+	+	+
Ashes (lessis)	+	+	+	

Neem (*Azadirachta indica*)

Neem is a wonderful insecticide, 100% natural, nontoxic to humans and animals, active against more than 200 insects, mites, grasshoppers, les nematodes, fungi, and bacteria. The active ingredients in *Azadirachta indica* are found in all parts of the tree, but are most concentrated in the seed.

- For seed, make pesticide from 12 kg/ha.
- For leaves, make pesticide from 80 kg/ha.

Preparation and application of neem leaves pesticide against crop pests

In order to make **15 liters of liquid,**

Use **3kg of fresh neem leaves at around 17h** (15 fistfuls corresponds to 3kg of leaves).

Place the leaves in a big pot and add 15 liters of water.

Boil the mixture until the green of the leaves disappears. This takes 30 to 45 minutes depending on the intensity of the fire heat.

Allow liquid to cool during 24h.

The next day around 17h, filter the mixture with fine cloth.

Add 15 ml of liquid soap or diluted soap.

Preparation and application of <u>neem seeds (fruit)</u> against crop pests

Gather mature neem seed (fruit) - especially those that fall to the ground.

Dry on a mat in the shade during one week. Place them in jute bags to use later.

Remove the fruit husk to get at the kernels inside, after storage in a dry aerated place.

For immediate use:

Soak the fruits in water during 5 hours. Wash them well to separate the kernel from the pulp.

Dry the kernels on a matt for one hour.

Use 1 kg, about 12 Nescafe coffee containers or 7 tomato cans of 400g size.

Use 500 g of seed (5 ½ measures in a Nescafe container, or 3 ½ of the 400g tomato can) to pound into powder.

Place the powder in a bucket and add 10 liters of water

Mix the concoction, cover the bucket, and let it soak for up to 24 hours before using for treatment.



Filter it using a sifter and cloth or just a cloth. Pour the solution into the sprayer.

Treat an area up to 400 m2 with 10 liters of the solution.

- *Frequency of treatment: once per week*
- *Treat only in the evening, after 17h, to avoid sunshine, as neem solution is sensitive to sunlight.*

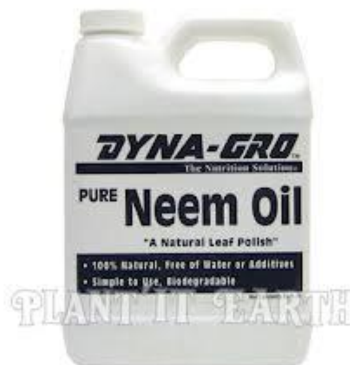
Using soap to help even out pesticide application pesticide

- Place the neem powder in a bucket and add 9 liters of water instead of 10; let it soak until the next day.
- The next day, before crop treatment, pound a pice of white soap, and place two 3-fingered pinches of the soap powder into a liter of water.
- Stir until the soap is all dissolved.

NB: Mix remaining solid particles of neem with soil from the nursery to fight beetles in the soil.

Neem oil

Products with a neem base are sold in the United States as ‘green’ pesticides or in Europe. However, neems do not grow in these countries.



In Niger, we have these neem products; we should be using them.

NB: Seed cake, obtained after pressing oil out of neem kernels, can be mixed directly with the soil at a proportion of 3 kg per 2 liters. The effect on nematodes is noticeable.

Neem is only weakly toxic, so it is ideal for diversified gardens with many types of vegetables, where producers visit every day to harvest vegetables to bring home to the household.

Note

Plants should be treated regularly to maintain steady coverage of neem solution on all parts, as the solution is a repellent only to make the plant unappetizing to pests such as beetles.

Once treatment is done, the producer will not immediately see dead beetles as with chemical pesticides.

Hot Pepper (*Capsicum frutescens*)

Mature fruit has insecticide properties, with active ingredients concentrated in fruit pouches and in the seeds.

- **Mode of action:** Toxicity by ingestion; insecticide, insectifuge, repellent, fumigation, and antiviral.
- It is particularly effective **against tomato and cabbage caterpillars, aphids and chinch**

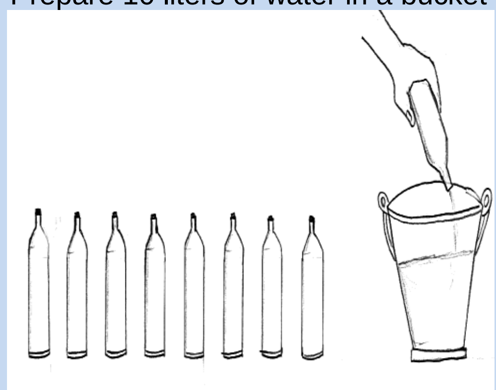
Preparation of 10 liters of solution with hot pepper pods

1. Use 250g of hot pepper fruits (measured as 2 ½ cans that held 400g of tomato)

2. Pound the fruits till ground

3. Wrap the pounded hot pepper in a cloth

4. Prepare 10 liters of water in a bucket



5. Around 17 h, soak the pounded pepper in the 10 liters of water.

6. Cover the bucket; leave it to soak for 24 h.

The day of treatment:

- *After stirring, press and squeeze the cloth wrapping into the bucket; filter the liquid*
- *Pound a piece of white soap and place 3 three-finger pinches of soap powder into a liter of water; stir it well*
- *Add the liter of soapy water to the bucket and stir well to obtain 10 liters of pepper pesticide.*

Tobacco

Preparation of 10 liters of tobacco leaves:

1. Use 200 g of dry tobacco leaves

(2 medium-size tomato cans 400g)

2. Pound into powder

Continue as for hot pepper:

3. Wrap the powder in a cloth
4. Pour 9 or 10 liters of water in a bucket; at 17h, soak the clothful of tobacco powder in the bucket
5. Cover the bucket and soak it for 24 hours

The day of treatment:

- *After stirring, compress the wrapped soaked powder several times, take it out of the bucket and filter the juice*
- *Pound a piece of white soap; add three 3-finger pinches to a liter of water and stir*
- *Add the dissolved soapy water to the 10-liter bucket and mix well*

Garlic

1. Make a mash: 20g of garlic soaked in 20 ml of vegetable oil for 24 hours
2. Add to the oil, 1 liter of water and 10 ml of biodegradable soap; mix
3. Filter the mix; the result is concentrated.
4. Dilute the concentrated liquid in **4 times its volume of water** before use for treatment

Mixture: 100g of garlic cloves are soaked in 10 liters of cool water for 24 hours

Boil for 15 to 20 minutes.

Cover while the concoction cools.

Add 10 ml of liquid soap to filtered concoction before treating plants in the evening around 17h.

Ashes (Lessis)

Lessis is a mash made of soaked ashes.

1. Place 2kg of ashes in a bucket and fill with 5 liters of water.

2. Stir the mixture a little and let it sit all night.

3. The next day, the ashes will be concentrated at the bottom of the bucket. Filter the liquid.

2 kg of ashes

Soak in 10 liters of water and all night

Pour the clear liquid (lessis) off into a watering can

Water garden crops directly with the lessis

To control cabbage, carrot, and onion flies and larvae, water plants with lessis after filtering.

Cultivation techniques to control pests

Complementary crops

One example is given to show how crops grown in association can discourage pests:

Garlic or onion and tomato can be produced with cabbage to fight crucifer worm. The secondary crops can be planted at the same time as cabbage, or 2 to 4 weeks earlier. Garlic and onion reduce infestations better than tomato.

Solarization

- The idea is to raise the temperature of the soil to kill nematodes
- Cover the soil with transparent plastic after abundant watering
- Water transmits the heat captured by the plastic as UV rays pass through it and destroy pests

1. Cleaning the garden plot

2. Deep hoeing to a depth of 25-30 cm

3. Leveling off

4. Abundant watering: 20 liters of water per square meter

5. Place clear plastic without wrinkles so it has direct contact with the soil, avoiding the creation of air pockets. Take it off after 2 or 3 months

NB: Solarization is used during hot months (March to May or September to October) to increase soil temperature most efficiently. The technique is especially recommended for small plots, for example in garden nurseries.

SAFER PESTICIDES USE POSTERS FOR AN IPM MANUAL

Attention aux enfants, au ménage, aux personnes sensibles

La plupart des pesticides sont toxiques. Il faut les garder sous clef hors de la portée des personnes qui ne les connaissent pas et à l'écart de tout aliment dans un endroit sec, aéré et aussi frais que possible.

Ne jamais mettre les enfants and les femmes à l'application des pesticides chimiques

Ne jamais traiter en présence de personnes, surtout les femmes enceintes

- Eviter le contact des pesticides avec la peau, les yeux

IL FAUT BIEN SE PROTÉGER EN PRÉPARANT and EN UTILISANT LES PESTICIDES

Éviter tout contact avec la peau en portant des vêtements, bottes and gants en caoutchouc uniquement réservés pour faire les traitements.

- ▶ Bien fermer les récipients des produits après usage
- ▶ Ne pas laisser les récipients au soleil
- ▶ Ne pas allumer du feu à proximité des pesticides

PRÉCAUTIONS À PRENDRE POUR L'UTILISATEUR and SON ÉQUIPEMENT

Lavez les gants avant de les retirer, dans un seau dont le contenu sera épandu de la même façon que les eaux de rinçage (évitez de laver les gants sous le robinet ou à l'évier).

Rincez les mains à l'eau claire puis lavez-les avec du savon. Jetez les gants percés, perméables ou souillés à l'intérieur.

Le déshabillage doit obéir à un ordre rigoureux précis, les gants enlevés en dernier and les vêtements retirés avec les gants, après qu'ils aient été rincés.

Lavez les équipements de protection imperméables avec un détergent and les placer dans une armoire-vestiaire individuelle destinée à ce seul usage, dans un local autre que celui de stockage des produits.

...ou utilisez des combinaisons jetables réservées strictement à l'application des produits phytosanitaires.

(Article 7 and 8 du décret N° 87-261 du 27 mai 1987 relatif à la protection des utilisateurs de produits phytosanitaires, Niger)

Ne jamais traiter à l'encontre du vent and sans équipement de protection

PRODUIT POUVANT S'ENFLAMMER FACILEMENT

Ne pas traiter aux heures chaudes de la journée ni quand il y a trop de vent.

Ne pas fumer, manger ou boire pendant toute la durée du traitement and pas avant de s'être douché.

(Article 10 du décret N° 87-261 du 27 mai 1987, Niger)

ACTIONS À ENTREPRENDRE

...si accidentellement le pesticide est en contact avec la peau :

- il faut immédiatement laver l'endroit souillé avec de l'eau propre.

...si le pesticide atteint les yeux : avant d'aller consulter un médecin,

- il faut les laver immédiatement avec des copieuses quantités d'eau propre.

...si par mégarde quelqu'un avale un pesticide, il faut :

- ▶ *Prévenir les secours d'urgence, le médecin and le centre antipoison, muni de l'emballage and de l'étiquette du produit en cause*
- ▶ *Ne pas faire boire, surtout jamais de lait ni d'alcool*
- ▶ *Ne pas faire vomir, sauf si l'étiquette du produit en cause le prescrit and seulement si la victime est consciente*
- ▶ *Si la victime est à peine consciente, ou si elle ne l'est plus, la mettre en position latérale de sécurité, la tête sur le côté, and la couvrir*

Disposition des produits restants, containers ou emballages

Emballages Vides de Produits Phytosanitaires (EVPP)

Dès que l'emballage du pesticide est vide, il faut le **détruire and l'enterrer profondément** dans le sol

loin des points d'eau and loin des endroits habités ou cultivés.

- *Surtout ne pas utiliser ces emballages pour conserver des aliments ou des boissons.*

Ne jamais apporter l'équipement de traitement à la maison and mettre sa famille dans le lavage de cet équipement

DEVENIR DU RESTE DES PRÉPARATIONS

- **Diluez le reliquat** avec de l'eau claire (5 fois son volume).
- **Épandez le reste dilué – à vitesse supérieure** – sur le lieu de traitement, ou sur des surfaces à moindre risque (surfaces planes perméables, éloignées de tout point d'eau; friches, terre).
- **Prévoyez une réserve d'eau propre suffisante pour diluer le reste de la préparation.**
- **Rincez l'appareil de pulvérisation** si vous ne pouvez pas retourner à l'atelier.

Attention!

S'il vous reste de la bouillie, ne videz pas la cuve dans les égouts, dans la cour de l'atelier ou dans un fossé !

Ce sont des sources de pollution ponctuelles

DEVENIR DES EAUX DE RINÇAGE DU MATÉRIEL DE PULVÉRISATION

- **Rincez plusieurs fois la cuve and le circuit de l'appareil**; **pulvérisez les eaux de rinçage à grande vitesse sur la surface traitée**, ou une surface à moindre risque.
- Utilisez l'eau contenue dans la cuve de rinçage; ou veillez à disposer d'une réserve d'eau sur le lieu de traitement (10% de la capacité de la cuve).
- Faites un **nettoyage approfondi à l'eau avec une solution détergente** and rincer abondamment.
- Nettoyez également les filtres and les buses.
- Pensez à **contrôler and remplacer les pièces usées** ou fragiles (comme les buses) pour éviter les fuites.
- Pensez à utiliser un phyto-bac (bac étanche contenant du fumier ou de la paille, and permettant de recueillir les eaux de rinçage).

Attention! Ne videz pas les eaux de rinçage sur n'importe quelle surface

Note: Photos of pests and diseases may be copied from the first version of this PERSUAP and used for training materials.

ANNEX 7: PERSUAP REFERENCES

Baker EL, Zack M, Miles JW, Alderman L, Warren M, Dobbins RD, Miller S, Teeters WR (1978) Epidemic malathion poisoning in Pakistan malaria workers. The Lancet, January: 31–33.

Websites: Website references used to develop the Programmatic PERSUAP

International Treaties and Conventions:

POPs website: http://www.pops.int

PIC Website: http://www.pic.int

Basel Convention: http://www.basel.int/

Montreal Protocol: http://ozone.unep.org/new_site/en/montreal_protocol.php

Pakistan malaria poisonings: http://pdf.usaid.gov/pdf_docs/PNACQ047.pdf.

Pesticide poisonings:

http://www.aljazeera.com/news/2017/03/200000-die-year-pesticide-poisoning-170308140641105.html

IPM and PMP websites:

http://ipm.ucanr.edu/

http://edis.ifas.ufl.edu/topic_pest_management

Pesticide Research Websites:

http://extoxnet.orst.edu/pips/ghindex.html (Extoxnet Oregon State database with ecotox)

http://www.greenbook.net/ (pesticide Material Safety Data Sheets)

https://iaspub.epa.gov/apex/pesticides/f?p=PPLS:1 (EPA Registration)

Ecotoxicity:

http://alamancebeekeepers.org/wp-content/uploads/2012/01/Hazardous-Pesticides.pdf (pesticide toxicity to honeybees)

http://wihort.uwex.edu/turf/Earthworms.htm (pesticide toxicity to earthworms)

Safety:

https://www.epa.gov/pesticides/biopesticides (EPA regulated biopesticides)

http://ipm.ucanr.edu/index.html (IPM, PMPs and pesticide recommendations) https://www.epa.gov/pesticide-worker-safety/restricted-use-products-rup-report (Restricted Use Pesticides)

https://www.epa.gov/safepestcontrol/citizens-guide-pest-control-and-pesticide-safety (EPA Health & Safety)

http://www.epa.gov/pesticides/PPISdata/ (EPA pesticide product information)

Personal Protection Equipment (PPE):

http://www.dupont.com/products-and-services/personal-protective-equipment/chemical-protective-garments/brands/tyvek-protective-apparel.html

http://multimedia.3m.com/mws/media/565206O/3m-cartridge-and-filter-replacement-faqs.pdf

Pesticide Container Disposal Options:

https://www.epa.gov/pesticide-worker-safety/pesticide-containers

ANNEX 8: FIELD VISIT SCHEDULES, ORGANIZATIONS AND PEOPLE MET

PROGRAMME DE LA MISSION PERSUAP AU NIGER DU 04 AU 16 JUIN 2017

Date	Activités	Personnes rencontres	Position
06/06/17	Rencontre au niveau de la DGVA	**Issa Zibo**	Directeur General de la Vulgarisation Agricole
07/06/17	Rencontre au niveau de la DGPV	**Sidati Sidi Mohamet**	Directeur de la Logistique et des Equipements Phytosanitaires
		Mme Abdou Halima	Directrice de la Règlementation phytosanitaire et suivi environnemental
		Graba Madougou	Directeur des études biologiques
		Mounkaila Hamani	Chef de division et encadrement phytosanitaire
09/06/17	Rencontre au niveau de l'AGRIMEX	**Mahaman AbdelKader**	Responsable des achats et Techniques
	Rencontre avec les responsables de REGIS-AG et REGIS-ER ; Patrice	**Abdoulaye Lihida**	Coordinateur Régional REGIS-ER Maradi

12/06/17	Rencontre avec INRAN Maradi	**Ibrahim Baoua**	Enseignant-Chercheur Maitre de Recherche, Entomologie/Sciences de l'Environnement et aussi Membre du Comité Sahélien des Pesticides
		Issa Karim	Dr. Phytopathologiste pour les cultures pluviales
	Rencontre avec le DFAP PASAM-TAI/CRS	**Adamou Alirou**	Deputy Chief of Party
13/06/17	Rencontre avec la Direction Régionale de l'Agriculture de Maradi	**Harouna Zodi**	Chef du service régional de la vulgarisation Agricole et du transfert des technologies
	Rencontre avec la Direction Régionale de la protection des Végétaux Maradi	**Laminou Adamou**	Directeur Régional de la protection des Végétaux de Maradi
14/06/17	Rencontre avec l'Association des Grossistes et détaillants d'Intrants Agricoles de Maradi	**Daouda Chaibou**	Président de l'Association des Distributeurs des Intrants Agricoles de Maradi
	Visite des boutiques d'intrants et produits phytosanitaires	**Saadou mahamadou Laouali** **Bassirou Kane** **Laouali abdou Tranzi** **Djamilou Souley** **Sabiou Mahamane**	Tous membres de l'ADIA Régionale Maradi et distributeurs des Pesticides
15/06/17	Rencontre les départementaux de l'Agriculture et protection des Végétaux de Guidan Roumdji	**Zakaria Salifou**	Directeur Départemental de Développement Agricole de Guidan Roumdji
	Visite des OP des REGIS-AG et REGIS-ER	OP de Garin Yahaya	OP des producteurs culture pluviale, irriguée et décrue.

		OP de Hannou Gazane	
17/06/17	Rencontre avec l'équipe des spécialistes de REGIS-ER	Ayi EkUE	PMN P4 (Système de production pluviale Résilients) PM National et Régional Tillabéri.
		Issaka Housseini	PMN P2 (Horticulture nutritionnelle et commerciale)

Mission - appui élaboration PERSUAP (19 juin au 03 juillet 2017 – Burkina Faso)

Au 20.06.2017

17/06 – Arrivée Alan :

Dominique BASSOLE, agro-inputs & services specialist Tel. +226 62 70 23 76

Chauffeur – Abel Nikiéma – Tél. +226 60 19 63 30

Semaine 1 : 19 au 25/06/2017

Date	Objet	Concernés / contacts
Lundi 19/06	Rencontre avec DCOP – REGIS-AG	
	Matin : 8h - ***Rencontre REGIS-AG/REGIS-ER*** + Alan S. Echange sur le programme de la mission proposé et organisation des visites ;	REGIS-ER : Alain Ky Zerbo (Présentant Pays) REGIS-AG : Dominique BASSOLE, agro-input specialist, lead comp 3
	9h - Rencontre FAO	Traoré Souleymane (chargé programme Agriculture) Tél. 70 76 54 38 Sawadogo Madi (Assistant de Programme) Ouédraogo Victor
	11h - Echange avec DPVC	Bureau Tél. 25 36 19 15 DPVC – Ouédraogo Dieudonné Tél. 70 28 50 01 Sawadogo Basile 70 22 98 86 Sawadogo Abdel Ouad 76 81 86 28
	16h – Rencontre avec **REGIS-ER & REGIS**-AG	REGIS-AG : Bruno Ouédraogo (DCOP REGIS-AG), Dominique BASSOLE (agro-input specialist - Lead Comp 3- REGIS-AG), Emmanuel Kaboré (Spécialiste niébé)
Mardi 20/06	9h -Rencontre avec ***Direction de la Vulgarisation Agricole*** DVRD - Service des Bonnes Pratiques Agricoles	Traoré Albert, Directeur du Développement Agricole, Tél. 70 25 87 21
	Rencontre Fasonormes / APEX	Tél. 25 31 13 00 /25 31 13 01

		Personnes de contact - Yaguibou Gustave 71 29 84 33 E-mail : outalain@yahoo.fr
Mercredi 21/06	9h - Rencontre avec Direction Générale de la Préservation de l'Environnement (DGPE) – questions sur les POPs	Traoré Abou (Point focal convention de Stockom sur les POPs) Tél– 70 93 77 52 et 79 47 49 89 Sanfo Abdou Nouredine Bonkoungou
	11h - **Rencontre avec Laboratoire de Santé Publique** (contrôle Pesticides) –	Dr Bonkoungou Hamidou Tel. 70 02 45 31 / 69 05 61 22 ; bonkoungouhamidou@yahoo.fr
	14h - Rencontre avec **distributeurs intrants** : Association des Grossistes et Détaillants d'Intrants Agricoles (AGRODIA)	Ouédraogo Hubert (Responsable à Communication). Tél. 76 15 25 71 Sanou Alphone Tiemtoré Abraham (Spécialiste suivi-évaluation) Tél. 76 70 56 71
Jeudi 22/06	***Service en charge du contrôle des produits à l'exportation***	
	9h - Rencontre avec le Directeur de la Firme Bioprotect	Sawadogo Claude Arsène Tél. 70 22 48 41 (Ouaga) WWW.bioprotech-b.com
	ECOCERT International –	Yanogo Abdoulaziz 61 48 29 32 / 70 15 59 39
Vendredi 23/06	**Rencontre avec fournisseurs / formulateurs de pesticides**	
	LDC - Représentation Ouaga Tél. 25 34 36 51	Olivier Bidima

	– siège Bobo	Basile Cugniere Té. 68 56 94 06
Samedi 24/06	Travail interne mission	

Semaine 2 : 25/06 au 03/07/2017

Date	Objet	Concernés
Dimanche 25/06	Livre -	
Lundi 26/06	Ramadan – Libre	–
Mardi 27/06	Matin : Voyage Ouaga -Kaya 11h- Rencontre avec Equipe REGIS-AG et REGIS-ER (Kaya & Dori) Lieu rencontre bureau : REGIS-ER Kaya – Contact - Sadatou Tél. 63 93 45 00	*REGIS-AG :* Traoré Adame (coordonnateur niébé) + Sambaré Hama (Coordonnateur niébé) *REGIS-ER :* Yassia Kané
	Soir : 14h – Rencontre avec Union provinciale des producteurs de niébé du Sanmatenga à Kaya (Arrangement par REGIA-AG)	Membres Union : Ouédraogo R Maria Soulaga Mariam Ouédraogo Saïdou Ouédraogo Salif 78 30 22 15 Ouédraogo Hamago

		Sawadogo Boureima Simporé Moustapha Ouédraogo P Salam 70 67 00 67 Staff REGIS-AG : Dominique BASSOLE Traoré Adama Hama Sambaré
Mercredi 28/06	Rencontre avec ***Direction Régionale de l'Agriculture***	Pierre Kaboré Tél. 70 28 55 24
	Visite boutique intrants agricoles – membre de la section provinciale d'AGRODIA - Kaya	Paul Ouédraogo Tél. 70 22 53 27
	Visite boutique intrants agricoles – membre de la section provinciale d'AGRODIA - Kaya	Kabré Boukaré 70 02 19 07
	Visite boutique intrants agricoles – membre de la section provinciale d'AGRODIA - Kaya	Ouédraogo Salif
	Rencontre Direction Provinciale de l'Agriculture	Mr Sama Pierre Kaboré Tél. 70 28 55 24 (Directeur Provincial de l'Agriculture)
	Route – pour Fada	
Jeudi 29/06	Matin - 9h - Rencontre avec équipes projets de REGIS-AG & REGIS-ER Lieu : bureau de REGIS-AG à Fada	REGIS-AG : Abroulaye Sanfo (Small ruminant Value Chain specialist) Tel. 70 30 72 10 Sibiri Clément Lomppo (Poultry Value Chain Specialist Tél. 70 86 08 60)

		Antoinnette Tiendrébéogo (Admin & Accounting assistant) Dominique BASSOLE (Lead Comp 3, REGIS-AG) REGIS-ER : (absent)
	Soir : 14h – Rencontre avec OPs niébé ou Jardin potager pas loin de Fada (arrangement Rendez-vous, Bationo de REGIS-ER)	Non réalisé
	16h : Rencontre avec Direction Régionale de l'Agriculture de l'Est – Fada	Joseph Nikiéma Tél. 70 27 27 95
Vendredi 30/06	Matin : Rencontre avec Direction Régionale de l'Agriculture	
	Rencontre avec distributeurs d'intrants agricoles de la région de l'Est, section provinciale des distributeurs de Fada, membres d'AGRODIA	Djendéré Saïdou Tougouma Jules Kevin Ouango
	Visite unité de Bioprotech à Fada et rencontre avec le Président de l'ONG ARFA	Sawadogo Mathieu,

	Soir : Route pour Ouaga	
Samedi 01/07	Libre	
Dimanche 02/07	Libre	
Lundi 03/07	Matin : 9 h- Point de la mission de Alan avec les équipes projets de REGIS-ER & REGIS-AG Soir - Départ Alan – fin de mission	REGIS-AG : Bruno Ouédraogo (DCOP REGIS-AG), Dominique BASSOLE (agro-input specialist - Lead Comp 3- REGIS-AG), Emmanuel Kaboré (Spécialiste niébé) REGIS-ER : Patrice Beaujault

US FUNDS CANNOT BE UTILIZED TO PURCHASE OR OTHERWISE SUPPORT THE PESTICIDES LISTE

ANNEX 9: SUMMARY OF PESTICIDE AIS REGISTERED BY INSAH AND REJECTED BY THIS PERSUAP ANALYSIS

The REGIS Projects requested an analysis of all pesticides registered by INSAH for use in member countries, Burkina Faso and Niger. The first analysis was performed by AI, and a second analysis was performed by Products. Pesticide AIs not registered by EPA, RUP, Class I, known carcinogens and known water pollutants are rejected. The second analysis examined uses of Products, by Trade Name, to determine if INSAH registered them for commercial crops not targeted by REGIS, for rejection.

Note well that pesticide AIs listed directly below without a reason for rejection in parentheses are generally registered for commercial crops like cotton, sugarcane and rice, none of which are REGIS target crops.

Analysis of Pesticide AIs, with Rejections

Table 32. Fumigant AI in products registered by INSAH but Rejected for Training on, Promotion to, or Use on REAP Demonstration Trials by Smallholder Farmers (with reason for rejection)
• aluminum phosphide (Class I, RUP for all uses—Not safe for smallholder farmer or on-farm use)

Table 33. Fungicide AIs in products registered by INSAH, and recommended by this PERSUAP for BEO rejection for use in USAID projects (with reason for rejection)
• copper hydroxide • copper sulphate • pencycuron (not EPA registered) • propineb (not EPA registered) • pyraclostrobin

Table 34. Herbicide and PGR AIs in products registered by INSAH, and Recommended by this PERSUAP for BEO rejection for use in USAID projects (with reason for rejection)
• 2, 4 D potassium salt (not EPA registered) • 2,4-MCPA • aclonifen (not EPA registered) • bensulfuron-methyl • bispyribac-sodium • butachlor (not EPA registered) • chlorimuron-ethyl • cycloxydim (not EPA registered) • cyhalofop-butyl

Table 34. Herbicide and PGR AIs in products registered by INSAH, and Recommended by this PERSUAP for BEO rejection for use in USAID projects (with reason for rejection)
• dicamba • diflufenican (not EPA registered) • dimethenamid-P • diuron • epoxiconazole (PGR, also fungicide, not EPA registered) • fluazifop-P-butyl • fluroxypir-meptyl • haloxyfop R methyl (not EPA registered) • isoxadifen-ethyl (not EPA registered) • mepiquat chloride • mesotrion • metolachlor • metribuzine • oxadiargyl (not EPA registered) • penoxulam • pretilachlor(e) (not EPA registered) • prometryn • propanil • propaquizafop (not EPA registered) • pyrazosulfuron-ethyl (not EPA registered) • pyribenzoxim(e) (not EPA registered) • saflufenacil • s-metolachlor • tembotrione • terbuthylazine • terbutryn(e) (not EPA registered) • triclopyr • trifloxysulfuron-sodium

Table 35. Insecticide and Miticide AIs in agriculture products registered by INSAH, and recommended by this PERSUAP for BEO rejection for use in USAID projects (with reason for rejection)
• alpha-cypermethrin (also miticide) (RUP) • beta-cyfluthrin (RUP) • bifenthrin (RUP) • cartap hydrochloride (not EPA registered) • chlorantraniliprole • chlorfluazuron (not EPA registered) • chlorpyrifos-ethyl (not EPA registered for horticultural uses) • cyantraniliprole • cyfluthrin (RUP) • cypermethrin (RUP for horticultural uses)

US FUNDS CANNOT BE UTILIZED TO PURCHASE OR OTHERWISE SUPPORT THE PESTICIDES LISTE

Table 35. Insecticide and Miticide AIs in agriculture products registered by INSAH, and recommended by this PERSUAP for BEO rejection for use in USAID projects (with reason for rejection)
• deltamethrin (RUP for field horticultural uses, but GUP and approved only for indoor grain storage sack and warehouse uses) • diflubenzuron (RUP for horticultural uses) • emamectin benzoate (RUP for horticultural uses) • fenitrothion (also miticide) (not EPA registered for horticultural uses) • flubendiamide (not EPA registered) • fludioxonil • indoxacarb • lambda-cyhalothrin (RUP) • lufenuron • matrine/Sophora flavescens extract (not EPA registered) • methomyl (RUP) • profenofos (also miticide) (EPA registered only for use on cotton + RUP) • prometryn • pyriproxifen • spinetoram • spirotetramat • sulfoxaflor • tebufenpyrad (also miticide) (not EPA registered) • teflubenzuron (not EPA registered) • thiacloprid (not EPA registered)

Table 36. Insecticide AIs registered by INSAH for use in health and residential sector—NOT agriculture, and recommended by this PERSUAP for BEO rejection for use in USAID projects (with reason for rejection)
• allethrin (not EPA registered, for mosquito control) • bendiocarb (no longer EPA registered, for mosquito control) • camphre/camphor oil (for mosquito control) • citronella oil (for mosquito control) • clothianidin (for mosquito control) • d-allethrin (not EPA registered, for mosquito control) • d-trans-allethrin/bioallethrin (for mosquito control) • dimefluthrin (not EPA registered, for mosquito control, residential use) • esbiothrin (no EPA registered products, just AI, mosquito control, residential use) • imiprothrin (residential use) • meperflurthrin (not EPA registered, for mosquito control) • mepirmethrin (not EPA registered, for mosquito control) • silicone (not EPA registered, for mosquito control) • tetramethrin (for mosquito control)

US FUNDS CANNOT BE UTILIZED TO PURCHASE OR OTHERWISE SUPPORT THE PESTICIDES LISTE

Table 36. Insecticide AIs registered by INSAH for use in health and residential sector—NOT agriculture, and recommended by this PERSUAP for BEO rejection for use in USAID projects (with reason for rejection)
• transfluthrin (not EPA registered, for mosquito control, residential use)

Table 37. Nematicide AIs in products registered by INSAH, and recommended by this PERSUAP for BEO rejection for use in USAID projects (with reason for rejection)
• ethoprophos (also insecticide) (RUP) • oxamyl (also insecticide) (RUP)

US FUNDS CANNOT BE UTILIZED TO PURCHASE OR OTHERWISE SUPPORT THE PESTICIDES LISTE

Analysis of Pesticide Products, by Trade Names, with Rejections

Rejected Pesticide Products

Table 38. Fungicide AIs in products registered by INSAH (and reasons for rejection)

INSAH No	Active Ingredient	Product Trade Names with Formulation, if known	Concentration	WHO acute toxicity as listed by INSAH	Reasons for Rejection of Products
209	copper hydroxide (hydroxide de cuivre) also bactericide	Idefix	65.5%	II	most copper hydroxide products over 50% AI are EPA Class I toxicity, too toxic for smallholder farmers
189	copper sulfate, pentahydrate (Sulfate de cuivre pentahydraté) also bactericide	Golden Blue 985 SG	985g/kg	II	concentration is too high for safe use by smallholder farmers
92	fludioxonil + métalaxyl-M + thiamethoxam (I)	Cruiser Extra Coton 362 FS	8.34g/l + 3.34g/l + 350g/l	III	only registered for use on cotton
68 162 213	thirame + imidaclopride (I) thirame + imidaclopride (I) thirame +	Calthio I 350 FS Fox 45 FS Imidalm T 450 WS	100g/kg + 250g/kg 20g/kg + 25g/kg 100g/kg +	II II III	products only registered for use on cotton, pencycuron not EPA registered, chlorpyrifos-éthyl RUP for agriculture use

Table 38. Fungicide AIs in products registered by INSAH (and reasons for rejection)

INSAH No	Active Ingredient	Product Trade Names with Formulation, if known	Concentration	WHO acute toxicity as listed by INSAH	Reasons for Rejection of Products
270 350	imidaclopride (I) thirame + imidaclopride (I) + pencycuron thirame + chlorpyrifos-éthyl (I)	Monceren GT 390 FS Saloum 500 DS	350g/kg 107g/kg + 233g/kg + 50g/kg 250g/kg + 250g/kg	II III	
75/6 131 255/6 268	s-métolachlore + prométryn s-métolachlore s-métoloachlore + mésotrione + terbuthylazine s-métolachlore	Codal Gold 412.5 DC Dual Gold 960 EC Lumax/Primagold 537.5 SE Metonyx	250g/l + 162.5g/l 960g/l 375g/l + 37.5g/l + 125g/l 960g/l	III III III III	only registered for use on cotton, métolachlore known water pollutant
249	tembotrione + isoxadifen-ethyl	Laudis 630 SC	420g/l + 210g/l	III	isoxadifen-ethyl not EPA registered
39	triclopyr +	Baraka 432 EC	72g/l +	III	mostly registered for use on rice

Table 38. Fungicide AIs in products registered by INSAH (and reasons for rejection)

INSAH No	Active Ingredient	Product Trade Names with Formulation, if known	Concentration	WHO acute toxicity as listed by INSAH	Reasons for Rejection of Products
	propanil		360g/l		
66	triclopyr +	Calriz	72g/l +	III	
	propanil		360g/l		
169	triclopyr +	Garil 432 EC	72g/l +	II	
	propanil		360g/l		
412	triclopyr	Triclon 480 EC	480g/l	II	
234	trifloxysulfuron (sodium) + ametryne	Krismat 075 WG	1.85g/kg +	III	only registered for use on cotton or sugarcane
			73.15g/kg		
88	trifloxysulfuron (sodium) + prométryn	Cotofoce 80 WG	10g/kg +	III	
			790g/kg		

Table 39. Herbicide AIs in products registered by INSAH (and reasons for rejection)

No	Active Ingredient	Product Trade Names and Formulation, if known	Concentration	WHO acute toxicity	Reasons for Rejection of Products
1 196 261 345 349	2,4-D " " " "	2KD Super 720 SL Herbafor 720 SL Malo Binfaga 720SL Rivormore 720 SL Sahel 2D	720g/l 720g/l 720g/l 720g/l 720g/l	III II II II II	only registered for use on rice
127 197	2,4-D amine "	Dokat Herbalm 720 SL	720g/l 720g/l	II III	only registered for use on rice
200	2,4-D diméthylamine	Herbextra 720 SL	720g/l	II	only registered for use on rice
234	ametryne + trifloxysulfuron	Krismat 075 WG	73.15g/kg + 1.85g/kg	III	only registered for use on sugarcane
203 342 351 396	bensulfuron-méthyl " "	Herbiriz 10 WP Rimax 60 DF Samory Thera 10 WP	100g/kg 60g/kg 100g/kg 100g/l	III II III III	only registered for use on rice

Table 39. Herbicide AIs in products registered by INSAH (and reasons for rejection)

No	Active Ingredient	Product Trade Names and Formulation, if known	Concentration	WHO acute toxicity	Reasons for Rejection of Products
420	bispyribac-sodium	Wassa	40%	U	only registered for use on rice
167 362	clomazone + pendiméthaline clomazone + pendiméthaline	Galaxy 450 EC Sniper	150g/l + 300g/l 150g/l + 300g/l	III II	only registered for use on rice
339	chlorimuron-ethyl	Rebel 500 WG	500 g/kg	U	only registered for use on sugar cane
170	cyhalofop-butyl + fluroxypyr-meptyl	Garil Power	184.3g/l + 230.7g/l	III	only registered for use on rice
202	dicamba + nicosulfuron	Herbimais 240 OF	200g/l 40g/l	III	dicamba has drift issues that damage nearby crops
217	diméthenamid-P + safulfenacil	Integrity	600g/l + 58g/l	III	only registered for use on sugarcane
9 117 125	diuron " "	Action 80 DF Diablo 800 WG Diuralm 80 WG	800g/kg 800g/kg 800g/kg	III III III	only registered for use on cotton or sugarcane

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Table 39. Herbicide AIs in products registered by INSAH (and reasons for rejection)					
No	**Active Ingredient**	**Product Trade Names and Formulation, if known**	**Concentration**	**WHO acute toxicity**	**Reasons for Rejection of Products**
313 388 400	“ “ “	Power Tempra 80 WG Tianaba	800g/kg 800g/kg 800g/kg	III III III	
163/4	fluazifop-p-butyl	Fusilade Forte 150 EC	150g/l	III	only registered for use on cotton
62 87 201	fluométuron + prométryne + glyphosate fluométuron + prométryne fluométuron + prométryne	Callifor G Cotochem 500 SC Herbicoton DF	250g/l + 250g/l + 60g/l 250g/l + 250g/l 440g/l + 440g/l	III III III	only registered for use on cotton,
47 48 49 50 120 173	glyphosate glyphosate glyphosate glyphosate glyphosate glyphosate	Binfaga Massa Binfla 360 SL Binfla 720 WG Bintana 480 SL DigaFagalan/Finish360SL Glycel 710 SG	480g/l 360g/l 720g/kg 480g/l 360g/l 710g/kg	U III III III III II	only registered for use on cotton, rice or sugarcane,

Table 39. Herbicide AIs in products registered by INSAH (and reasons for rejection)

No	Active Ingredient	Product Trade Names and Formulation, if known	Concentration	WHO acute toxicity	Reasons for Rejection of Products
174	glyphosate	Glypha Plus 360 SL	360g/l	III	
175	glyphosate	Glyphader 360 SL	360g/l	U	
178	glyphosate	Glyphe	480g/l	U	
179	glyphosate	Glyphobar 480 SL	480g/l	III	
180	glyphosate	Glyphodaf 360 SL	360g/l	III	
182	glyphosate	Glypholab 360 SL	360g/l	III	
185	glyphosate	Glyphotrop 680 WSG	680g/kg	III	
186	glyphosate	Glysahel 41 SL	410g/l	U	
187	glyphosate	Glystar 360 SL	360g/l	III	
206	glyphosate	Herbo Total 360 SL	360g/l	III	
225	glyphosate	Kalach Extra 70 SG	700g/kg	U	
309	glyphosate	Piranha 360 SL	360g/l	III	
310	glyphosate	Piranha 757 WG	757g/kg	III	
315	glyphosate	Prodas 360 SL	360g/l	III	
316	glyphosate	Prodas Power	450g/l	U	
379	glyphosate	Suphosphate G 757 WSG	757g/kg	III	
380	glyphosate, K salt	Sunphosphate 360 SL	360g/l	II	
405	glyphosate, K salt	Toguna For 360 SL	360g/l	III	
406			450g/l	III	

Table 39. Herbicide AIs in products registered by INSAH (and reasons for rejection)					
No	**Active Ingredient**	**Product Trade Names and Formulation, if known**	**Concentration**	**WHO acute toxicity**	**Reasons for Rejection of Products**
407 426	glyphosate, K salt glyphosate, K salt glyphosate + oxyfluorfene	Toguna For 450 SL Toguna For 680 WSG Zoomer	680g/l 360g/l + 30g/l	III III	
116	MCPA/2,4-MCPA	Destroy 400 SL	400g/l	III	only registered for use on sugarcane
312	mépiquat-chloride (chlorure de mépiquat, a PGR)	Pix 5% SL	50g/l	II	only registered for use on cotton
222 255/6	mésotrione + métolachlore mésotrione + s-métoloachlore + terbuthylazine	Kabafla 710 SE Lumax/Primagold 537.5 SE	84g/l + 626g/l 37.5g/l + 375g/l + 125g/l	III III	métolachlore known water pollutant
84	métolachlore + terbutryne	Corignena 500 EC	333g/l + 167g/l	III	métolachlore known water pollutant

Table 39. Herbicide AIs in products registered by INSAH (and reasons for rejection)

No	Active Ingredient	Product Trade Names and Formulation, if known	Concentration	WHO acute toxicity	Reasons for Rejection of Products
90 192 266 391	métolachlore + terbutryne métolachlore + terbutryne métolachlore + prométryne métolachlore + terbutryne	Cotonet 500 EC Guerrier 500 EC Meprodaf 510 EC Terbulor 500 EC	333g/l + 167g/l 333g/l + 167g/l 380g/l 130g/l 333g/l + 167g/l	III III III II	only registered for use on cotton, terbutryne not EPA registered
410	metribuzine	Torpedo 480 SC	480g/l	III	only registered for use on sugarcane
65 291 343	oxadiazon " "	Callistar 250 EC Oxanet 250 EC Ristar 250 EC	250g/l 250g/l 250g/l	III III III	only registered for use on rice
426	oxyfluorfene + glyphosate	Zoomer	30g/l + 360g/l	III	only registered for use on cotton
10 38	pendiméthaline "	Activus 500 EC Bada/Diva 400 EC	500g/l 400g/l	III III	only registered for use on cotton, rice or sugarcane

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Table 39. Herbicide AIs in products registered by INSAH (and reasons for rejection)

No	Active Ingredient	Product Trade Names and Formulation, if known	Concentration	WHO acute toxicity	Reasons for Rejection of Products
153	"	Farmethalin 500 EC	500g/l	II	
303	"	Pendisuper 500 EC	500g/l	III	
167	pendiméthaline + clomazone	Galaxy 450 EC	300g/l + 150g/l	III	
362	pendiméthaline + clomazone	Sniper	300g/l + 150g/l	II	
73	penoxsulam + butachlor	Citadel	10g/l + 400g/l	III	only registered for use on rice
191	penoxsulam	Granite 240 SC	240g/l	II	
333	penoxsulam	Rainbow 25 OD	25g/l	III	
61	prométryn + fluométuron	Callifor 500 SC	250g/l + 250g/l	III	only registered for use on cotton, métolachlore known water pollutant
62	prométryn + fluométuron + glyphosate	Callifor G	250g/l + 250g/l + 60g/l	III	
75/6	prométryn + S-métolachlore	Codal Gold 412.5 DC	250g/l + 162.5g/l	III	
87	prométryn +	Cotochem 500 SC	250g/l +	III	

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Table 39. Herbicide AIs in products registered by INSAH (and reasons for rejection)

No	Active Ingredient	Product Trade Names and Formulation, if known	Concentration	WHO acute toxicity	Reasons for Rejection of Products
	fluométuron		250g/l		
88	prométryn + trifloxysulfuron-sodium	Cotoforce 80 WG	790g/kg + 10g/kg	III	
159	prométryn + fluométuron	Fluoralm P 500 SC	250g/l + 250g/l	III	
266	prométryn + métolachlore	Meprodaf 510 EC	130g/l + 380g/l	III	
392	prométryn + métolachlore	Tericot 500 SC	250g/l + 250g/l	III	
37	propanil + 24D	Baccara	260g/l + 175g/l	II	only registered for use on rice
			360g/l +		
39	propanil + triclopyr	Baraka 432 EC	72g/l	III	
			360g/l +		
66	propanil + triclopyr	Calriz	72g/l	III	
			360g/l		
150	propanil	Eureka/Propa 360	360g/l +	III	
169	propanil + triclopyr	Garil 432 EC	72g/l 360g/l	II	

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Table 39. Herbicide AIs in products registered by INSAH (and reasons for rejection)

No	Active Ingredient	Product Trade Names and Formulation, if known	Concentration	WHO acute toxicity	Reasons for Rejection of Products
204 308	propanil propanil	Herbisahel 360 EC Pinnacle 360 EC	360g/l	III II	
287	pyraclostrobin (PGR, also fungicide) + epoxiconazole (a fungicide)	Opera	133g/l + 50g/l	II	only registered for use on sugarcane
217	saflufenacil + dimethenamid-P	Integrity	58g/l + 600g/l	III	only registered for use on sugarcane

Table 40. Insecticide AIs in products registered by INSAH (and reasons for rejection)					
No	**Active Ingredient**	**Product Trade Names with Formulation, if known**	**Concentration**	**WHO acute toxicity**	**Reasons for Rejection of Products**
141 393	abamectine + emamectine benzoate abamectine	Emaba Tetrakill 20 EC	20g/l + 20g/l 20g/l	II III	emamectin benzoate is RUP for field agriculture and horticulture use, abamectine formulations above 1.9% are RUP, these products are only registered for use on sugarcane
4 11 20 27 60	acétamipride + alpha-cyperméthrine acétamipride + lufenuron acétamipride + alpha-cyperméthrine acétamipride + bifenthrine acétamipride + bifenthrine acétamipride +	Acces 25 EC Acuron Alfaceta Appach Callifan Extra EC	15g/l + 10g/l 32g/l + 120g/l 50g/l + 36g/l 32g/l + 120g/l 32g/l + 120g/l	II III II II II	most of these products are registered for use only on cotton, alpha-cyperméthrine, bifenthrine, cyperméthrine, lambda-cyhalothrin, emamectin benzoate are RUP for field agriculture and horticulture use

Table 40. Insecticide AIs in products registered by INSAH (and reasons for rejection)

No	Active Ingredient	Product Trade Names with Formulation, if known	Concentration	WHO acute toxicity	Reasons for Rejection of Products
71	cyperméthrine acétamipride +	Capt 88 EC	16g/l + 72g/l	II	
72	cyperméthrine acétamipride +	Capt 96 EC	24g/l + 72g/l	II	
74	spinétoram acétamipride +	Cobra 120 EC	64g/l + 56g/l	II	
81	cyperméthrine acétamipride +	Conquest C 176 EC	32g/l + 144g/l	II	
82	cyperméthrine acétamipride +	Conquest C 88 EC	16g/l + 80g/l	II	
91	indoxacarbe acétamipride +	Crotale	16g/l + 30g/l	II	
94	cyperméthrine acétamipride +	Cyperanet 88 EC	72g/l + 16g/l	II	
104	lambda-cyhalothrin acétamipride +	Danaya	16g/l + 30g/l	II	
110	deltaméthrine acétamipride + cyperméthrine	Delta Top 56 EC	32g/l + 24g/l	II	

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Table 40. Insecticide AIs in products registered by INSAH (and reasons for rejection)

No	Active Ingredient	Product Trade Names with Formulation, if known	Concentration	WHO acute toxicity	Reasons for Rejection of Products
118/9	acétamipride + cyperméthrine	Diacotox 88 EC	16g/l + 72g/l	II	
147	acétamipride + cyperméthrine	Emir 88 EC	16g/l + 72g/l	II	
148	acétamipride + alpha-cyperméthrine	Emir Forte 104 EC	32g/l + 72g/l	II	
232	acétamipride + alpha-cyperméthrine	K-Optimal	20g/l + 15g/l	II	
239	acétamipride + alpha-cyperméthrine	Lamanet 46 EC	16g/l + 30g/l	II	
246	acétamipride + indoxacarbe	Lampride 46 EC	16g/l + 30g/l	II	
288	acétamipride + lambda-cyhalothrin	Optimal Super	20g/l + 25g/l	III	
293	acétamipride + lambda-cyhalothrin	Pacha 25 EC	32g/l + 30g/l	III	
	acétamipride +				

Table 40. Insecticide AIs in products registered by INSAH (and reasons for rejection)					
No	**Active Ingredient**	**Product Trade Names with Formulation, if known**	**Concentration**	**WHO acute toxicity**	**Reasons for Rejection of Products**
319 338 353 386 394 395	cyperméthrine acétamipride + lambda-cyhalothrin acétamipride + cyperméthrine acétamipride + emamectin benzoate acétamipride + emamectin benzoate	Protector Plus 56 EC Razzia 208 EC Saveur/Lambdaquest 62 EC Tangana Thalis 56 EC Thalis FTE 112 EC	32g/l + 24g/l 64g/l + 144g/l 32g/l + 30g/l 32g/l + 72g/l 32g/l + 24g/l 64g/l + 48g/l	II II II II II II	
83	chlorantraniliprole	Coragen 20 SC	200g/l	U	only registered for use on cotton

Table 40. Insecticide AIs in products registered by INSAH (and reasons for rejection)

No	Active Ingredient	Product Trade Names with Formulation, if known	Concentration	WHO acute toxicity	Reasons for Rejection of Products
44, 45	cyantraniliprole	Benevia 100 OD	100g/l	III	only registered for use on cotton
34	imidaclopride + cyperméthrine	Attakan C 344 SE	200g/l + 144g/l	II	most of these products are registered only for use on cotton cyperméthrine, beta-cyfluthrine RUP for field agriculture and horticulture use pencycuron not EPA registered
68	imidaclopride + thirame	Calthio I 350 FS	250g/l + 100g/l	II	
89	imidaclopride + thirame	Cotomence 450 WS	250g/kg + 200g/kg	II	
162	imidaclopride + thirame	Fox 45 WS	25g/kg + 20g/kg	II	
213	imidaclopride + thirame	Imidalm T 450 WS	350g/kg + 100g/kg	III	
270	imidaclopride + thirame + pencycuron	Monceren GT 390 FS	233g/l + 107g/l + 50g/l	II	
272	imidaclopride + spirotetramate	Movento Plus	120g/l + 120g/l	III	
397/8	imidaclopride + beta-cyfluthrine	Thunder/Solomon 145 O-Teq	100g/l + 45g/l	II	

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Table 40. Insecticide AIs in products registered by INSAH (and reasons for rejection)

No	Active Ingredient	Product Trade Names with Formulation, if known	Concentration	WHO acute toxicity	Reasons for Rejection of Products
32 35 91 102 208 214 215 271 288	indoxacarbe " indoxacarbe + acétamipride indoxacarbe " " " indoxacarbe + acétamipride	Asset 150 EC Avaunt/Steward 150 EC Crotale Dalica 150 EC Indox 150 EC Indoxan Moran 30 DF Optimal Super	150g/l 150g/l 30g/l + 16g/l 150g/l 150g/l 50g/l 300g/l 25g/l + 20g/l	III III II III II III III III	only registered for use on cotton
11 114 146	lufenuron + acétamipride lufenuron + emamectine benzoate lufenuron + emamectine benzoate	Acuron Denim/Match Fit 50 WG Emaron	120g/l + 32g/l 400g/kg + 100g/kg 80g/l + 20g/l	III III III	only registered for use on cotton, emamectine benzoate RUP for field agriculture and horticulture use

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Table 40. Insecticide AIs in products registered by INSAH (and reasons for rejection)

No	Active Ingredient	Product Trade Names with Formulation, if known	Concentration	WHO acute toxicity	Reasons for Rejection of Products
126 166	malathion malathion	Djigikan 800 EC Fyfanon 925 UL	800g/l 925g/l	III III	only registered for use on cotton and locusts
284-6 336 337	perméthrine perméthrine + transfluthrin perméthrine	Olyset Classic, Olyset Net, Olyset Plus Rambo NIS Rambo Powder	20g/kg 0.2% + 0.25% 0.6g/l	III II II	only for use on malarial mosquitoes, roaches, ants
6	pyrimiphos-méthyl	Actellic 300 CS	300g/l	U	only for use on malarial mosquitoes
145 311	pyriproxyfene + emamectine benzoate pyriproxyfene	Emapyr Piripro	60g/l + 20g/l 100g/l	III III	emamectin benzoate RUP for field agriculture and horticulture use, only registered for use on cotton
74 332	spinétoram + acétamipride spinétoram	Cobra 120 EC Radiant 120 SC	56g/l + 120g/l	II III	only registered for use on cotton

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Table 40. Insecticide AIs in products registered by INSAH (and reasons for rejection)					
No	**Active Ingredient**	**Product Trade Names with Formulation, if known**	**Concentration**	**WHO acute toxicity**	**Reasons for Rejection of Products**
272 401/2	spirotetramat + imidaclopride spirotetramat + flubendiamide	Movento Plus Tihan/Movento Total 175 O-Teq	120g/l + 120g/l 75g/l + 100g/l	III III	only registered for use on cotton, flubendiamide not EPA registered
5	sulfoxaflor + lambda-cyhalothrine	Acero 84 EC	48g/l + 36g/l	II	only registered for use on cotton
92 137 149 399	thiamethoxam + fludioxonil + metalaxyl-M thiamethoxam + lambda-cyhalothrine thiamethoxam + lambda-cyhalothrine thiamethoxam +	Cruiser Extra Coton 362 FS Eforia 045 ZC Engeo/Alika 247 SC Tialam 247 EC	350g/l + 8.34g/l + 3.34g/l 30g/l + 15g/l 141g/l + 106g/l 141g/l +	III II II II	only registered for use on cotton, lambda-cyhalothrin RUP for field agriculture and horticulture use

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Table 40. Insecticide AIs in products registered by INSAH (and reasons for rejection)					
No	**Active Ingredient**	**Product Trade Names with Formulation, if known**	**Concentration**	**WHO acute toxicity**	**Reasons for Rejection of Products**
	lambda-cyhalothrine		106g/l		

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ANNEX 10: A SHORT SYNOPSIS OF AFFILIATIONS AND BIOS FOR AUTHORS AND CO-AUTHORS

ALAN SCHROEDER BIO

Alan Schroeder was raised on a small family farm in the beautiful Susquehanna River Valley in upstate New York, the same place where the powerful Haudenosaunee (People of the Longhouse) Confederacy held sway for over 600 years prior to European colonization. While the First Nations peoples grew the "Three Sisters" crops of corn, beans and squash, Alan's father, Electrical Engineer Samuel Schroeder, grew every vegetable, fruit, spice and cut flower crop growable in the seasonal temperate upstate NY climate. This occaisionally included poultry as well—chickens and ducks and their eggs were often fine table fare, hand-raised at home. At a very young age, Alan and his brother Daniel, true entrepreneurs, set up a roadside stand to sell garden vegetables, fruits and cut flowers to passersby. The income earned, plus copious scholarships, helped put Alan and his brother through college. This wonderfully rich rural agricultural environment and entrepreneurial spirit served as a powerful inspiration to Alan as he pursued his life's dream: to work with farmers on diverse and exotic crops in other countries.

Alan trained as a Crop Protection and Agribusiness Specialist. With over 28 years of experience gaining knowledge, skills and abilities researching, writing, analyzing and reducing pest/disease risks to agriculture production, chemical and pesticide risks to humans/natural resources, and now risks from climate changes, Alan takes great pride to assist developing country farmers with expertise in agriculture, an understanding of USAID regulations, as well as formal training and practical experience in entomology, plant pathology, chemistry and agriculture business around the world. Farmers in some 60 to 70 countries have taught Alan how they survive with their agricultural skills in challenging and ever-changing environments. NGOs have taught him how they make a difference every day in the lives of these farmers, by introducing and applying new crop production tools and techniques.

Alan began his career in international development by being selected in 1989 as a Postdoctoral Research Fellow at CIMMYT, the International Maize and Wheat Improvement Center near Texcoco, Mexico. In 1990, he won a prestigious Science and Diplomacy Fellowship through the American Association for the Advancement of Science, working with USAID's Bureau for Africa on agriculture research networks across Africa, and during which time he lived in Burkina Faso. He next served for nine years as an International Program Leader through USDA Agriculture Research Service, where he provided policy advice, technical leadership, vision and management input on invasive trans-national locust, armyworm, bird and rodent plagues, as well as complex and sensitive international environmental challenges. He provided integrated pest management expertise as well as pesticide safety, management and disposal advice for upper-level USDA and USAID administrators, US Ambassadors, and United Nations officials.

During 2001, Dr. Schroeder founded E-NoeTec Consulting, from which he has worked as an International Consultant on agriculture and environmental compliance issues ever since. He recently spent two years living in Belgium, where his wife, Dr. Sonia Ortega, served as the

Science Attaché to our USA Embassy to the EU, and during which time he developed a European arm to his consulting business. He can be reached at alanschroeder99@gmail.com.

DOMINIQUE BASSOLE BIO

Dominique Bassole has more than 20 years of professional experience including almost 13 years focus in agro-inputs and services. His experience has been marked by independent consultant contracts and institutional contracts. Dominique currently works for CNFA in the project of Resilience and Economic Growth in the Sahel Accelerated Growth (REGIS-AG – USAID contractor) as agro-input and services specialist-lead component 3 for Niger and Burkina, since March 2015. Dominique worked in turn for the International Fertilizer Development Center (IFDC) and for Oxfam Solidarity Belgium.

At IFDC for 5 years (May 2011-April 2014), Dominique served for three years as the Chief of Party for the project « Professionalization of Agricultural Input Distribution (PRODIB) » in Burkina Faso, financed by Alliance for Green Revolution in Africa (AGRA) and previously for 2 years (April 2005 to May 2007) as National Coordinator of the Agricultural Input Supply Capacity Building Project (PRECAIA) funded by the Swiss Cooperation. Dominique trained more than 900 agricultural input distributors and ensured their link with producer organizations. The intercountry exchange organization allowed him to have knowledge of West Africa inputs system and agro-dealer organizations in particular, Ghana, Mali, Senegal, Côte d'Ivoire, Togo, Benin, Guinea Bissau, agro-dealers. At the Oxfam in Burkina Faso, Dominique held the position of Program officer for Food Sovereignty for nine years (2000-2005) and (2008-2011) where Dominique worked on several agricultural and problematic sectors including value chain approach of rice, organic cotton, land, market access, in Burkina Faso and Mali.

Dominique developed concept notes and proposals for the resource mobilization for the implementation of these projects in Mali and Burkina Faso. Dominique assumed the function of independent consultant for at least 5 years and made more than thirty missions between 1994-1999 and authored dozens of books.

Dominique holds a Diploma of M.Sc. Agro-economy from the National Institute of Higher Education in Agronomy (INFSA) of Mostaganem, Algeria and Dominique received several trainings including Management Results Oriented (RBM) and recognized as a trainer of trainers by Cropelife and IFDC. He can be reached at dbassole@regisag.net.

YAOU SALIFOU BIO

Mr. Yaou Salifou started working from January 2006 and has about 12 years of experience in International Development and Agricultural project in Niger. Mr. Salifou joined the CNFA team in 2017 working as input supply and Agricultural Market services advisor, the position which he occupies to date. He also worked with international and national NGO in Niger where he gained and developed his skills and experiences after his education. In both international and national NGOs, Yaou occupied several positions from field agent to project coordinator, program manager, advisor and research facilitator of trainings of farmers. Mr. Salifou also attended and participated in several online and physical trainings in building his own career and skills. The different positions Mr. Salifou held are as follow: Coordinator NGO Consortium CDR/ONDERNA, project for the Strengthening of Food Safety (PMERSA-MTZ), Maradi, Niger, January 2016-March 2017. His roles and responsibilities were to supervise, coordinate organize and facilitate technically the team work.

At World Vision where Yaou has most of his experience, he occupied different positions, as follow: Advisor, Food and Livelihood Security Programs World Vision Niger, Niger, January-December 2015; Resilience Program Manager, World Vision Niger, Niger, January-December 2014; Humanitarian Affairs Manager (includes management of food and non-food) and Emergencies, Food Security and Livelihoods, World Vision Niger, Niger, February-March 2013; Regional Development Programs Manager World Vision Niger, Damagaram & Takaya, Niger, May 2011 and Chadakori Region, Niger, December 2009 to April 2011.

As PICS (Purdue improved Cowpea Storage) Coordinator, Mr. Salifou dealt with the use of triple bagging for cowpea conservation without the use of pesticides. Project financed by the Bill and Melinda Gates Foundation, World Vision Niger, Niger, August 2008 to November 2009; Assistant Coordinator, PICS or project for the project to use a triple bag for cowpea conservation without the use of pesticides. Project financed by the Bill and Melinda Gates Foundation, World Vision Niger, Niger, August 2008 to November 2009; Sponsor at the Goulbin Kaba Zonal Development Program (Sponsorship agent in GNK / ADP) World Vision Niger, Maradi, Niger, from February- August 2008.

Yaou was an employee at the Maradi Integrated Development Project or MIDP from January 2006 to January 2008, where he worked as facilitator in Agricultural Research development and extension agent for new agricultural techniques and technologies transfer to the producers. Mr. Salifou holds a BSc degree in Agriculture, with a Crop Protection concentration from Ahmadu Bello University, Nigeria 2005. He can be reached at ysalifou@regisag.net.